Certain you're not sure?

An inquiry into pedagogical strategies for teaching children how to manage uncertain knowledge about sustainability challenges

Rebekah L. Tauritz

Doctor of Philosophy
The University of Edinburgh
2019

Supervisors

Professor Pete Higgins, University of Edinburgh
Dr. Simon Beames, University of Edinburgh

Examiners

Dr. Yvonne Foley, University of Edinburgh

Dr. Gregory Mannion, University of Stirling

Thesis submitted in accordance with the requirements of the degree of Doctor of Philosophy. This research was conducted under the auspices of the Graduate School of Education and Sport, the University of Edinburgh.

Author’s declaration

I declare that, except where otherwise indicated, this thesis is entirely my own work. No part of it has been submitted for any other degree or professional qualification.

RTauritz

Rebekah L. Tauritz

Date: March 3rd, 2019

Abstract

The urgent and rapidly changing sustainability challenges facing society today require people to possess the competences necessary to deal with knowledge uncertainty. This inquiry examined teaching strategies for enhancing the development of uncertainty competences, which are defined as the knowledge, skills, strategies, dispositions, and values, as well as the ability to effectively mobilise these attributes to manage knowledge uncertainty. The study's rationale stems from the dearth of research specifically addressing teaching uncertainty competences in primary education, and the existence of even fewer studies that provide teachers with clear guidelines regarding how such competences can be developed by their students. The principal aim of the study was to more deeply understand the strategies and practices of educators who were teaching children about complex and uncertain topics.

This interpretive, multiple case study focused on Scottish children in the final two years of primary school, since these children are increasingly confronted with complex environmental issues, both inside and outside the classroom. Principal data collection involved one observation in each of four classrooms and three observations in one classroom during lessons about complex environmental topics. In total 133 children and five teachers participated. The classroom interactions between teachers and children were captured using audio recordings and field notes, and complemented by focus-group interviews with children and interviews with teachers. Secondary data were derived from children's assignments and teaching resources.

The findings indicate that a combination of complex and controversial topics, specific learning activities, teaching resources, and the employment of 'language of conditionality' – all purposely designed to welcome uncertainty into the classroom – may improve the development of uncertainty competences. Language of conditionality consists of vocabulary, grammar and questions of conditionality. The first two concepts refer to the words, grammatical rules and linguistic devices that allow clear and nuanced communication about the uncertainty and complexity inherent to sustainability challenges. The third refers to a variety of questions that invite uncertainty into the learning process. Teaching the language of conditionality lays a constructive groundwork for learning how to manage sustainability challenges. The study found that the classroom teacher who primarily used language of conditionality created space for the children to explore multiple perspectives, come with creative answers, question the certainty of knowledge, and practice dealing with uncertainty. The Teachers were often not aware of the ways in which their use of language of conditionality influenced learning. The research suggests there is value in incorporating this aspect of language choice and the discussion of uncertainty competences in teacher education.

Acknowledgements

Doing my PhD has for sure been one of the most complex and uncertain challenges I have ever faced. Along the way I learned a great deal about dealing with uncertainty in so many different guises. It has also been an incredible learning journey, which I could not have completed successfully without the support of my family, friends and colleagues. In fact, I might not even have started if it hadn't been for my family who urged me to go ahead, even without funding, to explore the issues which fascinated me and find out if doing research was the right path for me to follow.

Perhaps it all started when I began as a volunteer at Het Groene Wiel, the local environmental education centre in Wageningen in 2005. Dannie Wammes, you were one of my first environmental education mentors. It was during my time as a volunteer that you introduced me to the development of environmental education projects and it was then that I discovered that environmental education had become so much more than an 'enriched' biology lesson, as its transformed configuration had come to include such elements as sharing multiple perspectives, weighing interests, articulating values and decision-making. In fact, this is what made me decide after studying forest- and nature conservation, to pursue a degree in communication science and learning for sustainability at Wageningen University. There I met Professor Arjen Wals whose courses introduced me to theoretical perspectives of learning for sustainability and social learning. I remember many discussions about emancipatory environmental education. I wondered then if a teacher by encouraging a high degree of autonomy, self-responsibility, and self-determination, was not risking that the learner might end up making very different decisions than the teacher hoped for from a sustainability point of view. Years later I find myself confronted by teachers and professors who, just as I had done in Arjen's class, worried that my suggestions to use more language of conditionality and encourage questioning of complex and uncertain sustainability knowledge and knowledge authorities, were irresponsible, and could lead to children distrusting science or refuting contested and highly politicised perspectives such as the human contribution to climate change. In order to respond to their concerns, I spent considerable time weighing the pros and cons of this issue (See Section 1.3.2!) and queried how you can lower the risks. In the course of my study I have become convinced that if people are to transform our current society into a more just and sustainable one, they need to be equipped with uncertainty competences. And we need to accept the risk that they may make decisions that we have not anticipated, hoping, in case this were to happen, that their choices will ultimately lead to a better and perhaps even more sustainable society than the one we as teachers and researchers imagined. So much for being able to accept not knowing what will happen! Arjen, you gave me the opportunity to organise my first thoughts about the topic of uncertainty by writing a chapter about uncertainty competence development for one of the books that you edited.

My burgeoning ideas about teaching uncertainty competences ultimately led me to pursue a PhD degree at the University of Edinburgh in Scotland. I thank the Graduate School of Education and Sport for accepting me for their PhD programme and the University of Edinburgh for awarding me a Moray Endowment Fund grant which helped me to support and complete my research when every cent mattered. There are two people in particular, my supervisors Dr. Simon Beames and Professor Pete Higgins, who played an indispensable role on this PhD journey and to whom I owe my sincerest gratitude. If it hadn't been for your genuine interest in my topic of uncertainty competences and its relation to sustainability and outdoor education, as well as the trust you instilled in me that you would guide me safely through the PhD labyrinth, I might not have begun. From the start you were convinced I could do what needed to be done. I thank you for your trust in me and for finding the time to read my work closely and provide me with detailed feedback; I learned so much from this process! Through your kindness and authenticity, you created a safe learning environment in which I was able to explore my ideas, build confidence in myself and develop my own voice as a researcher.

I also want to thank my other colleagues from the outdoor and environmental education group for many enjoyable conversations we had over the years and for showing me that there are truly passionate, supportive and inspiring research groups in Academia. I look back with gratitude on the support from my outdoor education PhD colleagues (Shang-Zhan, Sharifah, Ethan, Jamie, Dave, June and Sho) who helped me organise a successful 3-day residential Outdoor and Sustainability Education Research Seminar, as well as many lunch-time research seminars. Jade, my dear Canadian outdoor education colleague, you inspire me with the way you embrace everyone you meet with the same warmth and honesty. Thank you for opening your home and your heart to me, so that I was able to travel to Canada and realise my dream of attending the World Environmental Education Congress in 2017. Andrew, I look back with a smile to all the times we distracted each other in the office with our interesting conversations. You happily shared your knowledge about life in Scotland and so many other things as well. I also look

back with a smile on the many conversations with my other education PhD colleagues, sharing our ups and downs and helping each other find essential information. I have lovely memories of our pot-luck lunches, badminton and table tennis lessons, playing Monopoly Edinburgh Edition, the March for Science, the Storytelling Workshop for PhD students at Moray House, a beach walk to beautiful Aberlady Bay, and the writing retreat at Firbush Outdoor Centre to name a few memorable moments of joy, rest and inspiration along my PhD journey.

My sincerest gratitude goes out to the five teachers who welcomed me into their classrooms. As we agreed that I would not mention your names with respect to my research I address you all with these words; you know who you are! You generously allowed me to observe lessons designed and taught especially for my research study and let me conduct interviews with the children and with you. Some of you have supported me over several years as I kept turning back to you with all sorts of questions about Scottish primary education. Thank you for sharing your ideas and experience with me and making me a better education researcher in the process.

I also want to thank you, Velda, for giving me the opportunity to work on the PTAS research project about teaching university students how to deal with wicked problems. Even though it was a challenge to combine it with the last few months of the PhD writing process, at the same time it stimulated my thinking. I am therefore grateful for your patience. It is a pleasure to work with you and our other colleagues, Andy, Sharon and Pete.

Now I turn to my friends in Scotland, who were such an important part of my Edinburgh Adventure. Caroline, it felt so good knowing I had a close friend in Scotland from the very beginning, even if you did live more than four hours away from me! Alette, we met in my first year in Edinburgh at the storytelling festival and began talking about the role of storytelling in sustainability education. A few months later you contacted me to ask if I would be interested in joining your storytelling group for which I am very grateful. I thought this was an excellent chance to work on my public speaking skills. However, I soon discovered that our storytelling coach, Michael, incorporated so much more into his coaching, making storytelling a beautiful and personal vehicle for self-reflection and development. Thank you for that Michael! Alette, I am also grateful that you brought Rodica, who was also in our storytelling group into my life. My dear friend Rodica, how I wish you were still here with us today… You taught me about being brave and helped me realise that I indeed had taken a brave decision in choosing the challenging PhD path in order to learn to stick my head above the parapet. Jessica, my friend and co-learner, I will forever cherish those years of together taking care of our share horse

Marley. Your eagerness to learn, explore and challenge yourself continues to inspire me. I have always maintained that learning to work with Marley was almost as big a challenge for me as my PhD and I could not have achieved either one without you there by my side, encouraging me, trusting my abilities. Iustina, I am so glad that Rodica brought us together. You are such a caring friend and I have warm memories of you cooking and baking Rebekah-proof dishes. It was also wonderful that I was able to stay with you, Dario and Victor when I had no flat of my own anymore in Edinburgh. Joe, you also generously offered your cottage when I needed a place to stay. With a smile I look back on our nature walks and honest conversations. Sally, thank you for welcoming me with open arms when I needed a place to stay. I love your eagerness to learn as well as to pass your knowledge about the environment on to others. Carla, I will fondly remember your contagious cheerfulness and your eagerness to help others. Andy, I want to thank you and Brechtje, and of course the cats, for your support during the long last stretch towards the viva. Rachel, I want to thank you for all your support over the years that I lived in Edinburgh. I admire and enjoy your love and dedication to animals and nature and your eagerness to learn and share your knowledge with me. I look forward to that fun road trip to visit Jessica in her ‘Highland horse world’! Liz, I want to thank you for opening your big and accepting heart to me. I enjoyed our many frank and interesting conversations during my visits to the farm.

And where should I begin with thanking my friends from back home for their love, support, patience, and encouragements which kept me going all those years… Marjoleine, it seems impossible to see you and not end up in hours-long conversations about life and reflecting together on who we are and want to be. You have always been there for me no matter how crazy my request for help. I treasure your unending support. Susan, I will never forget the hundreds of hours we worked together on our PhD’s even as we lived in different countries, keeping each other going, lifting each other’s spirits when we lost morale, authentically sharing our hopes and our fears, and in the process ensuring that we did not feel alone on this challenging path. Severine, I am so grateful for your re-assuring down-to-earth attitude, especially in helping me make sense of the philosophical research paradigm and guiding me through the maze of ideas surrounding interpretive inquiry. Marit, I look back on the many wonderful and thought-provoking conversations we have had about teaching children and I cannot wait to take more walks with you and continue talking and learning from your wisdom. Eva, for three decades you have been part of my life’s story, sometimes more in the foreground, sometimes a bit more in the background, but always present. You feel like a sister, who I know will be there whenever I need to reach out for support. Diliana, I want to thank you for the many letters and cards you sent me over the years, sharing your inspiring personal journey of self-reflection and making me feel supported and connected. Jetteke, you stimulated me through your own inspiring experiences with environmental education projects to go to Het Groene Wiel and become a volunteer. Thank you for that, as well as for your optimism and kindness as you cheered me on all these years. Marlon, we share a passion for environmental education, teaching and doing research; I treasure our stimulating conversations and your brilliant ideas for learning activities. Trees, thank you for the lightness you always seem to bring to our conversations about our shared passion for environmental education, as well as the ups and downs we encounter on our life's paths. Jolande, it never ceases to amaze me how well you understand me from just a gesture or a few spoken words; thank you for being there for me on my life's journey, for your encouragement and for sharing your inner wisdom. Dolinde, I am looking forward to finally having time again to go on nature walks with you and continuing our heart-to-heart talks that have inspired and taught me so much over the years. Dyana, I thank you for the lively phone calls over the years, especially while I was living in Edinburgh. I would say that I only had a wee bit of time, but once we began talking it was so hard to stop! And to my other dear friends, Natascha, Nicole, Dori and Harm, Laurien, Debby and Michel, Tuvit, Geertruida, Annemieke, Saskia and Jasper, Zus, and Hans, I thank you all for the many wonderful and inspiring conversations we have had over the years, and for always letting me know that you would be there waiting for me, whenever I returned from my Edinburgh adventures.

My teachers Eef and Marieke, I want to thank you both for the many lessons learned; through working and playing with horses you have taught me so much about daring to venture out into the unknown and experiment, challenging the status quo about teaching and training, and searching for deeper heartfelt truths, even when we discover that all we have known as truth can be questioned and replaced.

Finally, I return to my family. I want to thank my Mom, who went above and beyond to support me in each phase of the PhD process. She was not just the patient mother reassuring me whenever I lost my confidence, but also my English tutor, my editor and my critical friend who continuously challenged my thinking, ensuring that I learned so much more from this experience. I want to thank my Dad for his endless support with myriads of practical problems. I only had to suggest that I might have a problem, any sort of problem, for him to start working out how it might be fixed. I also remember a conversation I had with my brother Daniel, a dedicated university teacher, in which he asked me questions to help me figure out if I had the right mind-set to be a researcher. He asked if I liked to solve issues by applying known knowledge, or if I liked to solve them by coming with new ideas and theories. That helped me realise that more often than not when I had a question I was not satisfied with the available answers and felt compelled to search further, reconstruct the question, come with new concepts and keep digging. Thank you, Daniel! Over the years of my PhD Journey, I have been grateful to my sister Lara and her family for their support and patience. They have always made me feel included even though I so rarely made it to the family get-togethers. My family did get together, however, though we were not all physically present, in a very special way to co-create the title of my thesis. Thank you to all of you!

Preface

Sometimes I ask myself how I ended up amidst all of this uncertainty stuff. I grew up in the Netherlands as the youngest child of American immigrants, moving back and forth between cultures and languages. The love for animals and nature that I developed as a child ignited what later would become my passion for environmental education. The many teachers and academics in my family, who encouraged me to learn and ask questions, were another contributing factor. It was stressed that finding the right answer is important and that you should not give up until you find it. Little did I know then about asking the question: How do I actually know there is a right answer to be found?

After obtaining my Master's degree in Communication Science and Environmental Education, I worked for five years developing environmental communication projects and teaching materials for primary schools. I also volunteered at the local environmental education centre developing projects for primary school children and helping out when classes visited the centre. Ever since I entered the environmental education field I had heard the people around me talk about the need for moving towards a more sustainable world and how this requires people who are capable of handling complexity and uncertainty. Any time this came up, everyone, whether they were teachers, environmental educators, policy makers or academics, would nod in agreement. I nodded too, but then I would ask: How do you teach someone how to manage knowledge uncertainty? No-one could answer. This question pursued me.

I remember as a child feeling confused when I noticed inconsistencies between textbooks, for example, regarding the average length of a wallaby's tail. How could that be? Surely, there should be one right answer! Almost thirty years later, I can recall the feeling of uncertainty and uneasiness when I didn't know which book to believe. As an adult I was again confronted with the complexities and inconsistencies of the scientific world when one doctor's diagnosis and treatment plan disagreed entirely from another's. Again, I was confronted by the need to decide which knowledge authority to trust. My childhood feeling of uneasiness returned in full force. I often wondered over the years if, and how, I could have been better prepared for dealing with contradictory knowledge. But I also questioned if today's children growing up with an overwhelming amount of information and disinformation at their fingertips would experience knowledge uncertainty in the same way. Would they be similarly distressed when confronted with contradictory information?

Growing up bilingual (English and Dutch) in a family with a love for words and language has influenced my research in many ways. For one thing, it ensured that I would be able to communicate easily with the Scottish children and teachers. Even more importantly, this alertness to how language is used sparked my interest in the meanings and motivations behind the use of particular words and forms of speech employed by the teachers and children in my study employed, especially when they were talking about complex sustainability challenges. My affinity with teachers and at the same time my lack of a teaching degree were paradoxically both of value to me. The former meant that I came to this research with an appreciation for teachers' enthusiasm and creativity and the latter that, never having stood in front of a classroom, I was an outsider to the group I was studying, not limited by the common sense of what is familiar in a particular setting, and therefore more open to the power of surprise. This resulted in the teacher interviews becoming conversations in which we explored together what had taken place during the observed lesson and what we could learn from it

I started to search for more information and write research proposals about ten years ago. It is incredible how mainstream the topic of 'learning how to manage uncertainty and complexity' has since become. In addition to staggering numbers of scientific publications, I now frequently come across newspaper articles, education blogs, podcasts, webinars, as well as spiritual and self-help books about learning to deal with uncertainty. In 2014, I finally began my PhD journey at the University of Edinburgh; I was eager to learn more… but prepared to accept that there would be no single right answer.

Table of Contents

List of tables

List of figures

Chapter 1 Research context: Preparing for an unknown future

> When you become comfortable with uncertainty, infinite possibilities open up in your life. It means fear is no longer a dominant factor in what you do and no longer prevents you from taking action to initiate change.
>
> … If uncertainty is unacceptable to you, it turns into fear. If it is perfectly acceptable, it turns into increased aliveness, alertness, and creativity.
>
> Eckhart Tolle (2016, p. 274)

1.1 Introduction

My thesis is based upon the premise that formal education plays a pivotal role in preparing children for tomorrow's world. A world we can almost see and touch, but that will always be just out of our reach, and, in that sense, will remain unknowable - until tomorrow has become today. Although the future has always been unknowable, the rapid speed at which things are changing is often astounding. The education field acknowledges this challenge and searches for ways to best prepare our children for this never entirely knowable future (see Section 1.3). I started developing my ideas about uncertainty competences as vital tools for living in an uncertain world in 2009. It seems evident from the pervasive nature of the discussion about preparing for an unknown future that the importance societies around the globe attribute to this topic has increased considerably. However, there are still more questions than answers as to how to incorporate developing uncertainty competences in education systems. This study aims to contribute to finding these important answers (see Section 1.4) and has focussed in particular on the Scottish context.

In this first chapter I illustrate some of the sustainability challenges humanity is facing at present and will face in the foreseeable future. I argue that there is a need for developing skills and dispositions that specifically help us deal with these challenges. I examine what *21st century skills* and critical thinking theory have to offer in preparing children for an uncertain future. I then discuss why I believe these do not suffice and suggest why uncertainty competences could be the way forward (see Section 1.2).

1.2 The 21st Century: Age of Complexity and Uncertainty

In Section 1.2.1 I describe what characterises the societal landscape of the 21st Century, how it differs from what came before, and which challenges humanity may face in the future. Next I discuss how the field of education offers concepts such as *21st Century skills* (see Section 1.2.2) and *critical thinking* (see Section 1.2.3) as potential solutions for managing the uncertainty challenges we face. I will discuss some of their limitations and in Section 1.2.4 suggest how *uncertainty competences* could contribute to the efforts to prepare children for an unknown future.

1.2.1 Life in the Anthropocene: complexity, uncertainty and contradiction

Anthropocene

A general consensus among scientists views Earth's history as beginning with its formation approximately 4.5 billion years ago (Ozima, Korenaga & Yin, 2012). Although our own species, Homo sapiens, appeared on the planet about 200.000 years ago, it wasn't until much more recently that we entered the period often referred to as the Anthropocene. Nobel laureate Paul Crutzen (2002) popularised the term *Anthropocene* with which he describes a new geological epoch during which humanity—through rapid population growth, urbanisation, deforestation, farming, industrialisation and burning fossil fuel— is profoundly and permanently changing Earth systems. This has led to large scale environmental degradation, depletion of resources, pollution of oceans, mass extinction of plant and animal species, and escalating levels of greenhouse gasses, ultimately modifying and impacting every ecosystem on the planet (Malone, Truong & Gray, 2017). While geologists continue to debate when this *geological age* began (Malhi, 2017; Zalasiewicz, Williams, Steffen & Crutzen, 2010), the broad impact of humans on our planet seems unequivocally accepted.

Sustainability

Not only do these massive environmental changes threaten life on Earth. As Paul (1995) states:

> The world is swiftly changing and with each day the pace quickens. The pressure to respond intensifies. New global realities are rapidly working their way into

> the deepest structures of our lives: economic, social, environmental realities – realities with profound implications for teaching and learning, for business and politics, for human rights and human conflicts. These realities are becoming increasingly complex; and they all turn on the powerful dynamic of accelerating change. (p. 1)

Today's society faces many urgent challenges to its continued existence. These challenges are often summed up in terms of sustainability. It is important therefore to clarify what is meant by the concept of *sustainability*. Molnar, Morgan and Bell (2001) note that the idea of sustainability as a responsible use of the environment, so as to ensure the well-being and survival of existing human populations, as well as that of future generations, is found in many indigenous belief systems. During the 20th century this idea was increasingly incorporated in decision-making and more explicitly defined, although generally using other words. However, it was not until thirty years ago, when the World Commission on Environment and Development (WCED, 1987) released the report *Our Common Future*, that the concept of sustainability became a principle component of many national and international policy agendas. In this publication Brundtland - coined the concept *sustainable development* as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). Kajika (2008) notes that this concept incorporates the idea that "responsible development requires consideration of natural, human, and economic capital", sometimes referred to as the three pillars of sustainable development. The underlying message, that humanity needs to live within our planetary means, has been widely acknowledged. However, the definition itself, and the practical implementation of the concept, have been at the centre of fierce debates for decades.

This concept has been criticised, according to Harding (2006), on the grounds that it is unclear whose present needs should be considered and that it is impossible to know exactly what the needs of future generations will be. In theory it can be said that all of humanity's needs should be considered. In practice, when decisions need to be made it can be quite a challenge to respond equitably. A fourth pillar, culture, has been suggested by authors such as Nurse (2006) and Redclift (2005). They caution that it is important to include the role of culture in any definition of sustainable development, as culture shapes assumptions, perspectives, epistemologies and human interaction with the environment. Seghezzo (2009) adds that the WCED definition has also been challenged as being anthropocentric, in other words focusing on the needs and welfare of humans, instead of acknowledging the intrinsic value of nature and other species. However, this criticism is only partially appropriate as the report finishes with the message that “the strategy for sustainable development aims to promote harmony among human beings and between humanity and nature” (WCED, 1987, p. 73). Jabardeen (2008) points to the paradoxical tension between *sustainable*, pertaining to the protection of the biosphere, and *development*, pertaining to the stimulation of economic development. The latter is problematic as the current consumption rates of wealthy nations already place demands on natural resources well beyond the planet’s long-term carrying capacity. Ramsey (2015) stresses that *sustainability* and *sustainable development* are highly contested terms and that the hundreds of definitions are only meaningful in relation to specific contexts. This becomes evident when Basiago (1995) describes the different perspectives regarding sustainability held by biologists, economists, sociologists, urban planners and environmental ethicists. For example, biologists may emphasise “the need to save … the genetic diversity contained in plant and animal species” (p. 111), economists the need to prevent exhausting the natural resources on which modern production systems are dependent, and sociologists the need for equity regarding the availability and use of natural resources among different interest groups. The concept of sustainability should therefore include perspectives of the different stakeholders involved in any particular sustainability challenge. While each perspective may be valid, the priority given to solving any particular problem will vary per stakeholder.

After considering the shortcomings of the WCED definition cited above and reading the literature closely, it seems near impossible to come up with a neatly phrased definition that covers all bases. Perhaps one could say that as sustainability is a dynamic and holistic concept, it is only possible to offer a provisional description appropriate in a particular context. In other words, sustainability is an ill-defined concept which is continuously redefined (Wals & Lenglet, 2016). For my purposes I consider sustainability[1] to be an on-going *learning process* in which people guided by cultural values, ethical principles and available knowledge *make decisions* and *take actions* in order to achieve an *evolving future vision* for our planet. This vision encompasses a lifestyle designed to meet humanity's current needs without compromising the ability of future generations to meet theirs. To achieve this, the integrity of biological systems needs to be maintained (Basiago, 1995) and the intrinsic value of the more-than-human-world recognised (Malone, Truong & Gray, 2017). Sustainability is not about perpetuating a static equilibrium, but rather cultivating the resilience of individuals and communities, as well as environmental and economic systems, to respond effectively and equitably to ever-changing and therefore inherently uncertain conditions.

In this study I frequently use the term *sustainability challenges*. Examples are the plastic pollution of our oceans, climate change, refugee crises resulting from regional conflicts and our growing energy consumption. As I pointed out earlier in this section, humanity finds itself confronted with increasing numbers of serious sustainability challenges, especially as our awareness grows concerning "the complexity and interconnectedness of all systems – human, social, economic and ecological – and that the survival of any one system is interdependent on the health of the others" (Molnar, Morgan & Bell, 2001, p. 32). These problems are so complex and interconnected that there are no obvious right solutions. Tauritz (2016) proposes that "education should foster the development of humans who when faced with uncertainty do not become paralysed, but on the contrary, can act responsibly and constructively" (p. 91). Wals (2012) points out that Education for Sustainability focuses on enabling "citizens around the globe to deal with the complexities, controversies and inequities rising out of issues relevant to environment, natural heritage, culture, society and economy" (p. 10). His description illustrates the opportunities that Education for Sustainability could provide in developing resilient individuals and communities who can manage sustainability challenges.

[1] In this study I use the words sustainability and sustainable development interchangeably.

Learning for Sustainability

The term *Learning for Sustainability* (LfS) is employed in this study. First, because my research focuses on the Scottish educational context (see Section 2.6 and 3.3) it seems self-evident that the term for Education for Sustainability as it is used in Scottish schools should be employed. Second, because LfS is a broad term encompassing important developments and insights in three equally important educational domains. Although earlier employed by Sinclair (2008), the term became more firmly established due to the efforts of the Scottish *One Planet Schools Working Group* in 2012. During the government consultation, this ministerial advisory group discussed how at that time there was a noticeable dominance of *Global Citizenship* in schools in Scotland, as well as increasingly elsewhere in the world. The concept of global citizenship places little emphasis on the natural (rather than the human) dimensions of sustainability. The working group decided instead to bring the domains of Education for Sustainable Development and Global Citizenship together, whilst at the same time emphasizing our relationship to the natural world through direct experience by uniting them with Outdoor Learning (the third domain).

According to Higgins and Christie (2018), the aim of this newly established model was to develop "a whole school approach that enables the school and its wider community to build the values, attitudes, knowledge, skills and confidence needed to develop practices and take decisions which are compatible with a sustainable and more equitable future" (p. 557). The term LfS has gained traction and is increasingly utilised throughout Scotland. It is, for example, included in the General Teaching Council for Scotland (GTCS, 2012) Professional Standards. The latter requires Scottish teacher's commitment to LfS as an essential aspect of their professional teaching practice. LfS is also incorporated in *How Good is Our School? Version 4* (HGIOS4; see Education Scotland, n.d.; 2015). This policy framework supports self-evaluation by practioners and school leaders and has further established the high priority of LfS in Scottish education.

Knowledge uncertainty

Taking decisions that try to solve complex sustainability challenges is exacerbated by the need to address the ubiquitous nature, as well as the sheer amount, of uncertain and ambiguous information about the environment. Environmental information is frequently fragmentary, incongruous and contradictory. For example, though knowledge authorities such as the IUCN (International Union for Conservation of Nature) and IPCC (Intergovernmental Panel on Climate Change) disseminate comprehensive publications about the urgency and consequences of habitat destruction (Baillie & Butcher, 2012) and the harmful effects of *global warming* (IPPC, 2015, 2018), based on the work of leading scientists, there are still numerous unanswered questions regarding these complex processes. In addition, despite the weight of evidence being strong and counter opinions few, it can be quite challenging for those who have not studied the scientific language of probabilities to comprehend the sometimes contradictory scientific messages offered by experts[2]. Funtowicz and Ravetz (1993) speak of *post-normal times* filled with uncertainty, contested (scientific) knowledge, overwhelming complexity, and the need for re-assessment of our values. Being capable of managing *knowledge uncertainty* regarding sustainability challenges and having the ability to make value-based decisions are more important than ever (Goverse, 2013). In accordance with Barnett (2012) and Polasky, Carpenter, Folke and Keeler (2011), I suggest that learners should be equipped with the competences needed to make decisions that are sometimes based on fragmentary knowledge, whether resulting from a shortage of time or because insufficient evidence is available to justify a specific decision.

1.2.2 Are 21st Century learning skills the solution?

In addition to the sustainability challenges discussed earlier, there is also another important change discernible in the societal landscape, namely the ongoing transformation from an industrial society to a knowledge society (Voogt & Pareja

[2] The focus within this study has been on the confrontation with uncertain, complex and contradictory information provided by experts who disagree on theories and facts or possess incomplete information, as well as uncertainty that stems from values held by the involved actors making decisions. I did not focus on the uncertainty that results from purposeful misinformation. The latter concerns (dis)honesty, blurring borders between truth and lies, and deliberate deception.

Roblin, 2010). This transformation is inextricably related to the development of information and communication technologies (ICT) which have drastically changed our perception of knowledge authorities and the possibilities of gathering knowledge as well as communicating and collaborating with others. It has also confronted us with the need for new ways to assess the credibility and cognitive authority of knowledge sources. Voogt and Pareja Roblin (2012) reflect on the implications of ICT for our knowledge society in which there is less need for routine production workers and an increased need for workers who are good at communicating, problem-solving and mediating information. The competences—knowledge, skills and dispositions—needed to effectively participate in the knowledge society are often referred to by scholars and educators as *21st century skills*[3] (Griffin, McGaw & Care, 2012; Thijs, Fisser & Van der Hoeven, 2014; Trilling & Fadel, 2009; Voogt & Pareja Roblin, 2012). Even though some authors such as Barnett (2012) have questioned how anyone can know which competences to teach for an unknown future, others such as Thijs et al. (2014) note that there is not much discussion among scholars, educators and policymakers about the necessity for these competences. There continues to be little agreement regarding the specific competences that should be taught. Although the terms *competences* and *skills* are often used interchangeably, they are in fact not the same. Competences is a broader concept which refers to "the ability to use knowledge – understood broadly as encompassing information, understanding, skills, values, and attitudes – in specific contexts and to meet demands" (UNESCO, 2015, p. 40).

Various 21st century skills frameworks have been developed over the years, such as P21[4], enGauge [5], SLO/Kennisnet Model voor 21e eeuwse vaardigheden[6], OECD 21st Century Skills and Competences for New Millennium Learners[7], Key competences for lifelong learning: A European Reference Framework[8], and KSAVE/ATC21S[9]. Studies

---

[3] These 21st century skills are also sometimes referred to as *advanced skills* (Ledoux et al., 2013), and *key competences* or *key competences for lifelong learning* (European Commission, 2006).
[4] Partnership For 21st century skills (2009)
[5] Lemke, Coughlin, Thadani and Martin (2003)
[6] SLO and Kennisnet (2016)
[7] Ananiadou and Claro (2009)
[8] European Commission (2006)
[9] Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M. and Rumble, M. (2012)

by Voogt and Pareja Roblin (2010), Thijs et al. (2014) and Remmerswaal and Voerman (2016) have determined that there are competences which are represented in most of these frameworks, for example, communication skills, collaboration skills, ICT skills, critical thinking, problem-solving skills, civic responsibility, creativity and innovation skills. Other competences such as metacognitive skills, planning, self-direction, flexibility and adaptability appear in a limited number of the frameworks.

There is only minimal reference to learning how to deal with knowledge uncertainty and contradiction in two of the frameworks above. The enGauge framework makes two mentions of uncertainty (Lemke, Coughlin, Thadani & Martin, 2003). First it states that "students who are curious are more tolerant of ambiguity and less anxious in uncertain situations than students who are not curious" (p. 38). The authors consider this a personal characteristic and no suggestions are made regarding how this curiosity might be developed. Second, it states that "students who are risk takers are willing to tackle challenging tasks, even when success is uncertain" (p. 42). It is suggested that to become risk takers students need to experience a safe learning environment in which they are confronted with multiple perspectives and intellectually stimulating assignments. The other framework that mentions uncertainty and ambiguity, but not the need for safe learning environments, is KSAVE/ATC21S (Knowledge, Skills, Attitudes, Values and Ethics/Assessment and Teaching of 21st century skills). In the category 'Living in the world - life and career' Binkley et al. (2012) suggest a person should be able to "adapt to change" (p. 57) and see change and ambiguity as providing opportunities to adjust priorities. In addition, the authors note in the same category that to "manage goals and time" (p. 57) a person should be able to accept uncertainty, take responsibility and be able to self-manage. Suffice it to say that these meagre descriptions provide no clarity as to how these competences can actually be achieved. Though these frameworks of 21st century skills are often showcased as providing answers for learning how to function in our complex, profoundly uncertain and rapidly changing society, they provide few details. One of the 21st century skills that is mentioned frequently, but is not worked out in much detail in the frameworks is *critical thinking*. According to Halpern (2006), "critical thinking skills are needed whenever we grapple with complex issues and messy, ill-defined problems" (p. 6).

Further investigation of this concept and its relationship to dealing with knowledge uncertainty is warranted.

1.2.3 Is critical thinking the key to unlocking our ability to manage uncertainty?

There is widespread recognition that being able to think critically is an essential competence for working and living in today's society. However, there is a notable lack of consensus regarding its definition. Three prominent approaches to critical thinking have their roots in the academic disciplines of philosophy, psychology and education.

Philosophical approach to critical thinking

The roots of the philosophical approach in Western society go back to the age of Socrates, Plato and Aristotle. According to Sternberg (1986) philosophers have generally concerned themselves with an ideal concept of critical thinking which is not hindered by the messiness of real-world problems and practical limitations such as time constraints, availability of or incomplete information, and the limitations of human information processing. Paul (1995) defines critical thinking as:

> a unique kind of purposeful thinking, in which the thinker systematically and habitually imposes criteria and intellectual standards upon thinking, taking charge of the construction of thinking, guiding the construction of the thinking according to the standards and assessing the effectiveness of the thinking according to the purpose, the criteria, and the standards (p. 21).

According to Paul, critical thinking that meets these intellectual standards is: "clear, precise, specific, accurate, relevant, plausible, consistent, logical, deep, broad, complete, significant, adequate (for purpose), fair" (p. 131). The focus on the optimal critical thinker also becomes clear from Facione's (2000) assertion that "to teach for thinking one must nurture truth-seeking, open-mindedness, analyticity, systematicity, intellectual curiosity, confidence in the proper use of reasons and evidence, and maturity of judgement" (p. 80). Furthermore, Sternberg (1986) and Lewis and Smith (1993) describe philosophical scholars as principally interested in applying formal logical reasoning and argumentation rules, and seeking perfected ways of thinking, in order to decide what one should believe and do. This approach is not always relevant in a real-life context.

Cognitive psychological approach to critical thinking

According to Sternberg (1986) psychological researchers, as opposed to philosophers, generally focus on the ways in which people actually think whilst highlighting how personal limitations and contextual constraints can impose constraints on performance. Cognitive psychologists tend to view critical thinking in terms of the student's observable actions and behaviours rather than in terms of unobservable thought processes, formal argumentation theory and meeting *universal intellectual standards*. Lewis and Smith (1993) explain that psychologists typically include lists of skills and critical thinking procedures in their definition of critical thinking. Halpern (2006) defined critical thinking as:

> The use of those cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal directed—the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions, when the thinker is using skills that are thoughtful and effective for the particular context and type of thinking task. (p. 6)

Sternberg (1986) states that "critical thinking comprises the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts" (p. 3). He also cautions that, paradoxically, the psychological approach is often based on theories developed in experimental settings which may differ considerably from what is genuinely taking place in a classroom.

The educational approach to critical thinking

The third approach comes from the field of education and is represented by scholars such as Bloom and Krathwohl who developed the well-known Bloom's taxonomy (1956). Decades later Krathwohl was again involved when a team led by L. Anderson revised Bloom's taxonomy (Anderson, Krathwohl & Bloom, 2001; Krathwohl, 2002). According to Sternberg (1986), critical thinking in this field emerged from "classroom observations, test analysis, and process analysis of thinking in the classroom" (p. 6), although it has also been influenced by a mix of philosophical and psychological theories (Wang, 2017). Sternberg (1986) cautions, however, that the theoretical education concepts are often lacking in clarity compared to, for example, the psychological theories which have generally been refined in more depth. Moon (2008) points out that educators are typically focused on the pedagogical approaches that enable students to critically think. While many critical thinking skills as described above contribute to learning how to reduce uncertainty, not all uncertainty can be (immediately) resolved, nor is it always desirable to do so. I therefore propose that there is also a need to learn to tolerate (Tauritz, 2012a) as well as to cherish uncertainty (Tauritz, 2016) (see Section 2.3.3). This has led to the development of the theoretical concept of *uncertainty competences* referring to "the sets of skills, knowledge, attitudes and capabilities needed to handle uncertainty, ambiguity and complexity in diverse contexts" (Tauritz, 2016, p. 91). Although similar conceptualisations of uncertainty competences have been proposed by some scholars (Grothmann & Siebenhuner, 2012; Grothmann, Prutsch, Schauser, McCallum & Swart, 2014), Tauritz (2012a, 2016) was the first to address its educational significance. From this perspective, it can be positioned alongside the educational approach to critical thinking, as it is greatly influenced by what happens in the classroom and the teaching strategies teachers could employ to teach these competences.

1.2.4 Uncertainty competences as the missing link

As the name indicates, uncertainty competences, including the regularly discussed critical thinking skills such as the ability to find, evaluate and utilise information and the ability to judge the credibility of information sources, are all focused on skills needed to deal with inherently uncertain and complex situations. It is not about situations in which it is simply necessary to know where to get the required information to come to a straightforward and reasoned decision. Sustainability challenges, as I have shown, often cannot be solved through critically thinking alone for the simple reason that there is not one obviously right answer to be found. No matter how much time and how many resources are available, the situation is too complex and uncertain to ever possess full knowledge. In addition, there is the acknowledgement of multiple and conflicting perspectives that can be *right* at the same time. This kind of uncertainty can be utterly overwhelming and calls for competences that help a person to tolerate uncertainty. Jamie Holmes (2015) writes this in his book *Nonsense: The power of not knowing*: “Dwelling calmly among feelings of uncertainty, to be clear, *will* help you make a more rational decision. Accepting uncertainty for longer periods will improve your odds of making rational decisions, even when you’re nearly positive that you’re correct” (p. 79). Uncertainty competences will be discussed in Chapter 2 in more detail. In the previous section I have argued for the development of uncertainty competences in response to the sustainability challenges humanity is facing. An important next step is to consider how teaching these competences fits into current trends in the field of education.

1.3 Educating for an uncertain future

I agree with Jordan and McDaniel (2014a), that the purpose of education is “to help children prepare for life in a complex dynamic world” (p. 249). In the first part of this section I will examine some general trends in the field of education particularly relevant to teaching uncertainty competences. I will also reflect on some important issues regarding the ability of teachers to teach these competences. In the second part of the section I will explain why I have focussed on children in the upper primary years (children approximately nine to twelve years of age).

1.3.1 Education sector and uncertainty competences

Many school curricula are at their core still based on archaic pedagogic models that were aimed at pursuing neo-liberal market-force agendas, essentially preparing students for an industrial economy (Dumont, Instance & Benavides, 2010; UNESCO, 2015); this is, considering the ongoing transformation to a knowledge society, an obsolete perspective that requires significant change in how we think about curricula, learning and teaching. In an industrial society the focus of schools is on the development of factual and procedural knowledge (Anderson, 2008). According to Longo (2010) the educational system in many countries still focuses on standardised testing, often resulting in teachers *teaching to the test*. Welsh, Eastwood and D’Agostino (2014) define this kind of teaching as “decontextualised instruction” (p. 98). Moon, Brighton, Jarvis and Hall (2007) explain how teachers feeling time pressure when working to a strictly standardised curriculum often skim over materials, thereby neglecting (in part) teaching how to critically assess and creatively apply content knowledge. Test-driven education focuses on students giving the *right answer*, an approach based on the existence of certainties. Teachers in test-driven systems often avoid an open teaching process in which there are *multiple right answers*. It is, however, precisely this more uncertain and open teaching process which is needed in developing the conceptual and meta-cognitive knowledge required to excel in a knowledge society (Anderson, 2008). Sterling (2010) explains that there is a deepening understanding that "not only do current ways of thinking, perceiving and doing need to change in response to critical systemic conditions of uncertainty, complexity and unsustainability, but that old paradigms are the root of these conditions" (p. 19).

In short, there is tension between an educational system that was developed to serve an industrial society and its continuous economic growth models, and the educational needs of a rapidly changing society in which "knowledge, its acquisition and deployment for social engagement and economic production [are] at the heart of human development" (UNESCO, 2014, p. 9).

It should be said that there are an increasing number of countries that on a political level acknowledge the need for redesigning the educational system. In place of the contemporary content driven curriculum, countries such as Scotland (Scottish Executive, 2004; Education Scotland, 2017; Learning for Sustainability National Implementation Group, 2016), Finland (Finnish National Board of Education, 2004, 2016) and New Zealand (Eames, 2017; McDowall & Hipkins, 2018, New Zealand Ministry of Education, 2007) aim for a curriculum that ensures both the development of content knowledge, as well as a range of skills, capabilities and dispositions. In 2006 the European Union adopted a European Framework for Key Competences for Lifelong Learning, identifying the key competences citizens need to flourish, both privately and professionally (Education Council, 2006; European Commission, 2007; European Commission, 2018). Unfortunately, the competences needed to handle uncertain, ambiguous and complex information are for the most part not mentioned in much detail. The Finnish National Board of Education (2004) is an exception with their list of objectives related to the cross-curricular theme "Participatory citizenship and entrepreneurship" (p. 38). One of these objectives states "The pupils will learn to confront and deal with changes, uncertainty, and conflicts, and to act with a sense of enterprise and initiative" (ibid). How to achieve this objective is not addressed.

Although scholars increasingly emphasise the need for educational strategies incorporating uncertainty in the learning process (Barnett, 2012; English, 2013; Floden & Buchmann, 1993; Forrest, Judd & Davison, 2012; Fraser & Greenhalgh, 2001; Gabella, 1995; Gordon, 2006; Jordan, 2015; Morrison, 2008; Tauritz, 2012a; Valley, Fu & Jovel, 2017), there is a clear lack of empirical data demonstrating how theoretical models can inform the practice of education regarding teaching uncertainty competences, especially at the primary school level. I agree wholeheartedly with Ehrenfeld (2017) who writes that:

> without a significant investment in a future-friendly pedagogy of engagement, our children will be unprepared for the future they are facing, unprepared to solve the significant challenges we are leaving them, and unprepared to create a better, more equal, more just, world (p. 55).

While it is key to develop our understanding of what such pedagogy should look like, we also need to consider if teachers are ready to teach about dealing with uncertainty.

1.3.2 Are teachers equipped to teach uncertainty competences?

Until this point I have focused on the societal landscape and how economic, social and educational developments relate to the education sector's perspectives on preparing children for their future. However, even if we agree that new competences are required, and we further agree that uncertainty competences are among them, simply sending a directive to teachers would not be sufficient. Therefore, in this section my focus will be specifically on the question "Are teachers equipped to teach uncertainty competences?". In an informal conversation in October 2016 I asked teachers in the *Facebook group Scottish Primary Teachers* whether they thought that a confusing topic such as climate change should be taught in P6/P7[10]. And if so, what teaching

[10] P6 and P7 refer respectively to Primary 6, the sixth year and Primary 7, the seventh and final year of children's attendance at a Scottish primary school. Children in P6 are generally nine to ten years of age at the start of the school year and children in P7 ten to eleven years of age.

strategies they would employ. The following interchange between two primary teachers illustrates how different perspectives on knowledge uncertainty influence the teaching strategies they select and affects their ability to teach uncertainty competences. Elsa and Kira[11] discuss how they would teach about a confusing and complex topic such as climate change in P6/P7. Teacher Elsa would not avoid the controversy regarding climate change. She would tell children that there are *opposing views* and organise a debate. Kira, who teaches at a different school, does not agree that there is any controversy and would teach children the *facts about climate change*.

Kira	*I don't know if it would be helpful to ask the kids to form an argument that ignores the overwhelming facts!*
Elsa	*Good to be able to look at two sides of arguments and form your own opinion. Children should always be taught differing and opposing views.*
Kira	*Yes, but would you teach them to argue against gravity? It's just a theory you know.*
Elsa	*Everyone has different opinions and deserves to be listened to and thought about. If you want children to have one opinion about everything then by all means teach them one thing and don't let them hear other sides of the argument. I'm not saying climate change is wrong or right… children, need to be able to form their own opinions and be able to look at opposing views.*
Kira	*Of course they do, I wasn't suggesting brainwashing! To me the point is that there is actually a right answer to the question! By all means discuss whether there is a real controversy and opposing views backed up by facts!*
Elsa	*But there is plenty of debate out there regarding climate change. Different governments believe different things, some argue that we are not causing this and that it is just a part of what happens to the*

[11] The real names of these teachers have been anonymised by using pseudonyms.

planet over thousands of years. You can't say it's as clear cut as there is one opinion and it is right, and all the others are wrong.

Kira *There is no controversy in the scientific community … the point was that opposing views are not always equally valid. In a classroom, like it or not you are the expert. In some cases, like the answer to 6x3 you have a duty to know best.*

Both teachers make valid points. However, from the perspective of knowledge uncertainty and uncertainty competences there are important differences. Elsa emphasises that people have different viewpoints and that they should all be listened to. She talks about *looking at two sides of the argument, children forming their own opinions*, and there is *not one opinion which is right* and all others are wrong. Although, she does not deny anthropogenic climate change, she finds it important to share with the children that not everyone agrees. For example, governments have different perspectives. Elsa does not avoid knowledge uncertainty and seems more accepting of the possibility that there is not always an obvious right answer. On the other hand, Kira is convinced by the overwhelming amount of scientific evidence concerning humanity's contribution to global warming. She talks about the *facts*, the *right answer*, *opposing views aren't always equally valid*, about *being the expert in the classroom* and *the teacher's duty to know best*. She indicates that a debate could create uncertainty and children might stop believing the scientific perspective and a debate about this topic should therefore be avoided.

During my study I often encountered people who were so busy defending the scientific perspective that they wanted to avoid any discussion with children that might lead to a child not accepting the human contribution to climate change. This approach, of avoiding the existence of knowledge uncertainty regarding climate change, can leave children without support as they try to grapple with the inconsistent messages they pick up from, for example, their parents, news programmes, the media or their friends. Monroe, Plate, Oxarart, Bowers and Chaves (2017) suggest that teachers should, in addition to discussing the science, also support learners in making sense of the wider controversy. Which of the arguments raised are fuelled by scientific disagreement and which by political, economic, social, or other factors?

I suggest that climate change can also be an excellent topic with which to discuss the process of scientific knowledge production, and how that knowledge can be used to explain how the world works. Explanations are based on theories that can be examined and tested. Scientists set out to gather evidence to either support or refute a theory. Plutzer et al. (2016) explain that in the case of climate change, so much evidence has been gathered that the issue of, for example, sea levels rising more quickly because of human-caused climate change, is extremely well supported. In contrast, there is still knowledge uncertainty regarding *exactly how rapidly* sea levels will rise. A teacher can explain such distinctions and teach children to listen critically as they evaluate the information (an uncertainty competence!). What is the scientific evidence? How great is the consensus? Being able to respond in accordance with the underlying probability is yet another uncertainty competence. Acceptance or rejection of what begins as *merely* a theory is typically gradual. As more evidence accumulates, knowledge uncertainty decreases until the theory is either accepted or rejected. This has certainly been true of climate change *theories*. At some point they have become accepted as *scientific fact*. A scientific fact constitutes the best explanation of a phenomenon that we have at any given moment. In the case of climate change, for example, 97 percent of climate scientists agree "that humans are primarily responsible for recent warming trends through the burning of fossil fuels" (Branch, Rosenau & Berbeco, 2016). At the same time it should not be forgotten that a scientific fact may always be contested (see Section 5.21 and Section 6.3.4). Learning to cherish uncertainty is a concept that will be given further attention in Chapter 2.

The different perspectives held by teachers with respect to uncertainty form an important part of my research context. The context further incorporates the complex sustainability challenges associated with the Anthropocene, public policy organisations, NGOs and educational institutions responding to these challenges, and the children and their teachers trying to make sense out of the sustainability challenges they are confronted with. Earlier in this chapter, it was suggested that specific skills and dispositions have the potential to help people deal with these challenges (Tauritz, 2016). I commented that 21st century skills frameworks and critical thinking theory give only limited attention to dealing with uncertainty, leaving teachers without sufficient support in teaching children how to manage knowledge uncertainty. Teaching uncertainty competences aims to deal with that lacuna. The discussion between Elsa and Kira highlights that the way teachers themselves think about and deal with knowledge uncertainty directly affects their teaching, the choices they make regarding teaching strategies, and the way they communicate with the children.

1.3.3 Focus on final primary years

A question that has intrigued me over the years concerns the age at which the uncertainty of our world can be introduced to children in a productive manner, given that the adults who are charged with preparing them for an unknown future are themselves not always equipped to deal with the associated uncertainty. This section explains why I have chosen to focus on children in the final primary years by discussing the children’s world and some aspects of the child’s development.

A child's world

Any child’s world inevitably encompasses some degree of uncertainty and ambiguity, even if adults often try to shield children in so far as possible from potential doubt and bewilderment. Today’s children are growing up in a dynamic, interconnected and complex world in which they are confronted with an increasing number of sustainability challenges and rapid technological developments. Littledyke (2004) describes the ways in which children develop environmental awareness through family life, classroom discussions, environmental projects, the media, television programmes and books. For some children these environmental issues are far removed from their daily lives, but millions of other children around the world find themselves in very different circumstances. Some face the devastating effects of climate change first-hand (UNICEF, 2015). These children are physically vulnerable and/or experience psychological distress. They worry about the state of the environment and their future (Strife, 2012). Strife points out that “empirical evidence across cultures demonstrates that in many cases, children are fearful, cynical, and pessimistic about environmental issues” (p. 37). Authors such as Sobel (1996) warn that children may develop what he coined as “ecophobia—a fear of ecological problems and the natural world” (p. 5). Sobel is adamant that, to avoid this, children should not be confronted with potentially “overwhelmingly sad and conceptually complex [environmental] issues” (p. 28) before they are about nine to ten years of age. These concerns are echoed by Strife (2012) who additionally considers the current media focus on widespread sustainability issues to be one of the main drivers in enhancing ecophobia. Strife's (2012) analysis of 50 in-depth interviews with American children (ages 10-12) from urban areas showed that 70% of the children in her study mentioned being worried and fearful regarding environmental problems because of what they see and hear on the television, news programs and in movies.

Kelsey and Armstrong (2012) represent an alternate view. They discuss the need to acknowledge that children sense the sustainability challenges their communities experience and that it is important to create a safe space where the children's experiences of potentially frightening environmental issues can be discussed openly. Blanchet-Cohen (2008) suggests that it is important to nurture the environmental awareness and concern experienced by many early adolescents (10-13 years of age) in order to develop critically engaged citizens. Interestingly, most teachers in my study did not think that the average Scottish child nine to twelve years of age is very aware and/or knowledgeable about environmental issues.

From the above it becomes clear that children in middle to late childhood (roughly between seven and twelve years) encounter sustainability challenges that enter their world in one way or another. The literature provides a mixed picture of children and preadolescents' responses to these challenges, ranging from no concern or interest, even apathy, to true concern, commitment to pro-environmental behaviours, or feelings of psychological distress. In my view, educators should support children in middle and late childhood to handle the complex and uncertain environmental information that is entering their world (Tauritz, 2016).

Children's development in middle childhood

An important question that educators need to ask is whether children's cognitive abilities in middle childhood are matured enough for them to be able to learn how to manage complex and ambiguous information. In this section I will reflect on a selection of cognitive developments discussed in the literature indicating that children age nine to twelve (upper primary years) are ready to tackle these topics. This premise was also confirmed by the teachers in my study who were of the opinion based on their experience that many children of this age are ready to engage with complex issues and are able to venture beyond the security of unambiguous right and wrong answers.

Beck, Robinson and Freeth (2008) found that until around seven years of age children generally have difficulty understanding that ambiguous information has multiple possible interpretations and that delaying an interpretation can pay-off. The younger child might think she needs to make an interpretation whenever she can and that not taking a decision is not an option. Another theory proposed by Acredolo and Horobin (1987) is that younger children cannot yet resist making an interpretation and that the first referent they find is accepted as the right interpretation. Around seven years of age children who are faced with taking a decision or judgment based on ambiguous information, start developing a more appropriate response such as "stating their ignorance, seeking out disambiguating information, or perhaps making a tentative interpretation" (Beck et al., 2008, p. 253). Lagutta and Sayfan (2011) point out that children develop significantly between four and ten years of age with regard to their understanding of "ambiguity, indeterminacy and counterfactuals" (p. 316).

Studies by Koerber, Mayer, Osterhaus, Schwippert and Sodian (2015) and Piekny and Maehler (2013) revealed the emergence of *domain-general scientific reasoning skills* (the reasoning abilities that are necessary for inquiry processes) during middle and late childhood. Doing research requires, according to these scholars, amongst other things the ability to generate hypotheses and the ability to evaluate evidence. The latter refers, for example, to evaluating *perfect covariation* (a statistical measure that shows a clear pattern between the variables), *non-covariation* (a statistical measure showing that there is no notable pattern between the variables), and *imperfect covariation* (a statistical measure showing that one or two hypotheses are predominantly favoured over another, but without a convincing pattern). The ability to recognise and evaluate unambiguous evidence showing perfect covariation or non-covariation generally emerges in pre-schoolers and early primary school children, roughly between ages four and eight. The ability to understand evidence indicating an imperfect covariation and drawing conclusions from these ambiguous findings, however, seems to develop non-linearly during middle and late childhood.

According to Rodríguez, Kohen and Delval (2015), the ability to reason about complex environmental systems central to sustainability challenges depends on the establishment of specific cognitive abilities which mature progressively during childhood and adolescence. The first of these abilities involves "recognizing hidden dimensions of systems and, thus, understanding natural phenomena through patterns and interrelationships that are not observed on the surface" (p. 77). Children up to approximately eight to ten years of age, they suggest, understand environmental phenomena mainly through sensorial perception and are generally not aware of parts of the system that are not visible. Children between 10-12 years develop the ability to understand and explain some interrelationships between parts of the system, but still have difficulty with parts they cannot see. As the children transition into adolescence they develop the capacity to realise a more conceptual understanding of environmental systems. The second ability is "making generalizations and thus solving environmental problems based on an understanding of systems' mechanisms" (p. 77). The third ability involves "thinking temporally, that is, representing the temporal distance between an [antecedent] and its consequences" (p. 77). Understanding temporal relations is required for establishing causal connections between what happened in the past, the present and the future. It is also important to develop a "temporally differentiated sense of the future" (Friedman, 2011, p. 398). In other words, it is necessary to develop an understanding of how near or distant future events actually are. Pronounced developmental changes take place regarding the ability to reason, make inferences, and represent mental models according to Johnson-Laird and Byrne (2002). Children between nine and eleven years progress from being able to employ just one mental model to being able to employ two mental models. The development of these inferential reasoning skills continues into adolescence. Rodríguez et al. (2015) suggest that reasoning can be improved by working with concrete information. I conclude from this that, in addition to the developmental progression, it is important for educators to realise that these reasoning skills and the use of mental models can be improved even more by teaching and the use of concrete (environmental) knowledge.

Children start to understand that beliefs may be held with differing degrees of certainty as young as four years of age (Moore, Pure & Furrow, 1990). It takes years longer, generally around six-eight years, before children grasp that a speaker can also hold different degrees of uncertainty. In addition to understanding the concept of *holding differing degrees of certainty and uncertainty*, children also learn over time how to use the language necessary to express their degree of certainty. See Chapters 5 through 8 for a discussion of the related findings, as well as Chapter 10 for a more in-depth developmental perspective on the use of language for expressing degrees of certainty.

In this section I suggested that educators need to support children in middle childhood in learning how to manage uncertainty; even when adults try to shield children from the potential anxiety these complex sustainability challenges may cause, the confrontation is unavoidable in today's world. It seems prudent to help them understand, prepare for and deal with these issues as soon as possible. Since children in middle childhood are in the process of developing and refining the abilities necessary to better understand and cope with complex and ambiguous information, as described in this section, it would seem like the appropriate time to introduce the topic in the classroom. We must then ask how educators can best support these children. What kind of teaching strategies would be beneficial for this age group?

1.4 Study rationale and significance

In this section I outline the rationale for my study, the research aim, and the objectives, as well as the significance of this study with regard to the field of education.

1.4.1 Research aim and objectives

I believe that preparing students for living and working in our rapidly changing society and teaching them uncertainty competences is relevant across the broad spectrum of education. However, I also specifically address the confrontation with sustainability challenges. These challenges make it necessary to critically assess our actions, our beliefs and dispositions, as well as the way we have organised our communities, in order to move towards a more sustainable and resilient society. This is one of the central themes in LfS and I believe that my work regarding uncertainty competences has the potential to make a specific contribution to that field. In Chapter 4 I discuss why the topics central to LfS are particularly suited for developing uncertainty competences.

Being able to handle complex and uncertain knowledge is often seen as a premise for sustainable development (Mayer & Tschapka, 2008; Remmers, 2007). Experts, however, generally offer limited guidance to teachers regarding how they can support the development of such abilities. The principle aim of my study is, therefore, to develop our understanding of how to teach children in an educational setting the competences they will need to manage complex and uncertain (environmental) knowledge—particularly when confronted with contradictory information. Such information may be inconsistent, incomplete, ambiguous or very complex. Sometimes it comes from actors belonging to different societal groups such as educators, policymakers or researchers. These actors tend to have differing conceptions, knowledge, experience, interests, goals and values. On other occasions the actors belong to the same societal group, as when two scientists or two doctors both present a seemingly well-argued but contradictory case. Sometimes we find ourselves in a situation where we have to decide which expert to believe. When people can't cope with these events, negative feelings of doubt and fear of making mistakes may arise. Some people may experience so much stress that they start making rash decisions or become so blocked that they can't make any decisions at all. With the competences needed to handle this uncertainty in place a different picture can emerge in which people experience creativity and energy, have the ability to make decisions confidently, and can collaborate successfully with others.

Some people seem naturally to thrive on uncertainty (Sorrentino, Roney & Hanna, 1992), while others can learn relevant skills and dispositions. In the context of this study I have focussed on the value of teaching uncertainty competences to all children, but particularly to those who do not naturally thrive on uncertainty. Figure 1.1 displays different scenarios that might unfold when an individual or group is confronted with uncertain and ambiguous information. It seems plausible that a person requires different sets of uncertainty competences to deal with each of the scenarios. This study's main objectives are to observe teachers' practice and explore both those teaching strategies teachers are seen to employ in the classroom and those which suggest themselves as additional strategies teachers could employ to teach children about managing complex and uncertain knowledge.

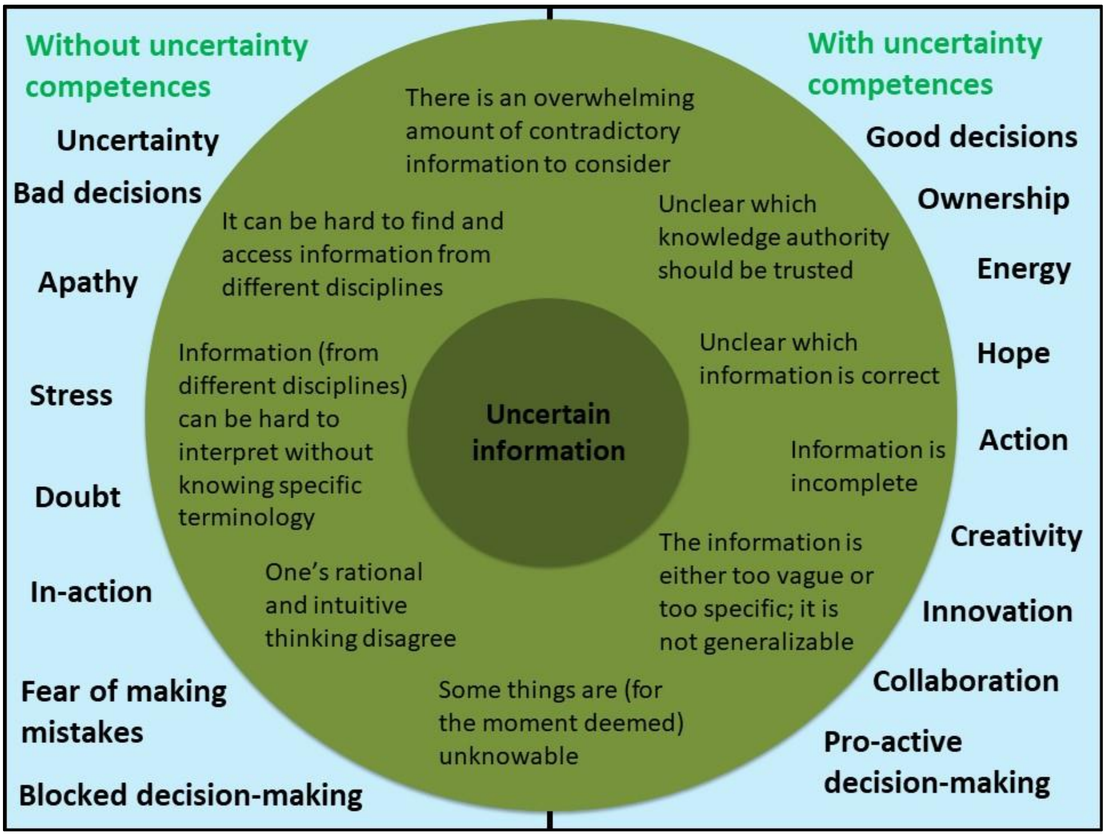

Figure 1.1: Various scenarios in which someone is confronted with uncertain information

1.4.2 Significance of the study

The past decade has seen an accelerating interest in the topic of preparing students for working and living in our evolving knowledge society. As was discussed in Section 1.3.1 an increasing number of countries are acknowledging the need for the field of education to adapt in order to better prepare students for a changing future and are therefore already incorporating critical thinking, LfS practices and other 21st century skills in their education policy. In Section 1.2 I indicated that many scholars have emphasised the importance of learning how to support students in developing relevant knowledge and skills. Perkins (2014) tells us that we desperately need to reimagine education in order "to address the lives that today's learners are likely to live in our dizzyingly complex contemporary society" (p. 5). From the previous sections, it becomes clear that this pertinent and complex issue, despite the attention it has received, has not led to satisfactory solutions. I have spoken to many teachers over the years who have told me they did not know how to teach about complex sustainability challenges to primary school children even though they often felt it was important to be able to do so. Although some of the critical thinking skills have been looked at in-depth (see Section 1.2.3), I have found that there are also uncertainty competences that remain neglected. Examples of such uncertainty competences are: being able to accept not knowing (what will happen or what the right answer/action is), and being able to use uncertainty as a catalyst for creative action. The study's rationale stems from the call for children to be prepared to thrive in times of accelerating change alongside the dearth of research specifically addressing teaching uncertainty competences in primary education. With this study I set out to further our understanding of teaching uncertainty competences and to find answers that could eventually lead to clear guidelines for primary school teachers regarding how these competences can be developed in their children.

In the following chapter I describe how I arrived at the aim, objectives and rationale I have enumerated above. Further, I discuss a selection of important uncertainty concepts found in the literature as well as some of the limitations of these concepts with respect to the principle aim of my research. I also establish the conceptual framework for my study, based in part on earlier published work (Tauritz, 2012a; 2016) and refined with respect to the research questions formulated in the present study.

1.5 Thesis structure

The first chapter provided an introduction to the nature and subject of this inquiry and established the research context. It included a discussion of some of the urgent sustainability challenges humanity is facing and what role education may play in preparing children for dealing with the associated complexity and uncertainty of these challenges later in life. I argued why I think it is important to specifically develop uncertainty competences in order for people to better be able to deal with present and future challenges. In this last section of Chapter 1, I share briefly what the reader can expect in the upcoming chapters.

Chapter 2 discusses my reading of the literature with regard to teaching how to manage knowledge uncertainty and presents the conceptual framework that guided my study.

The two central concepts: *uncertainty competences* and a *learning environment conducive to the development of uncertainty competences* receive detailed discussion. The literature review concludes with the research questions which I set out to answer in this study.

The third chapter details the methodological basis of this inquiry. This study employs an interpretive research approach that draws on elements of the hermeneutic method and abductive inquiry, utilising multiple case studies. Data was collected during classroom observations, focus group interviews with children and interviews with the teachers. Interpretive content analysis was employed. Together I believe this provides a methodologically sound investigation of the teaching strategies the five observed teachers employed while teaching about complex and uncertain sustainability challenges in the upper primary years.

Chapters 4 to 8 present the findings of my study per theme. The chapters are preceded by *A Guided Walk through the Findings Chapters*, which explains to the reader what to expect from these chapters. Two new concepts that emerged during the data analysis: *teaching strategies for uncertainty competence development* and the *language of conditionality* are discussed in detail. In Chapter 9 I summarise the teaching strategies employed in each of the five case studies.

Chapter 10 presents a final discussion in which I answer the research questions, discuss my study’s main contributions to knowledge, and reflect on the implications for practice. I include a developmental perspective on teaching the language of conditionality supporting my suggestions that it is appropriate to teach uncertainty competences, and in particular the ones related to the language of conditionality, in the upper primary years. Next four suggestions are made for further research. I conclude the chapter with a final look at the Revised List of Uncertainty Competences.

1.6 Summary

This chapter describes the societal landscape in which we find ourselves, confronted by a range of serious and complex contemporary sustainability challenges. I have also explained that, although some people think it is better to shield children from these complex challenges and the associated ambiguous information, children encounter these challenges nonetheless. In addition, the literature suggests that children in the upper primary years (nine to eleven years of age) have developed or are developing many of the rudimentary cognitive abilities needed to deal with knowledge uncertainty. It has also become clear that to be able to deal with the current as well as future challenges we need to equip citizens with appropriate competences. Whilst in this chapter I have simply made the case for the overall aim of enhancing our understanding of teaching uncertainty competences needed when confronted with uncertain and contradictory information, in Chapter 2 the concept of such competences will be discussed in detail. Teaching uncertainty competences calls for a special approach to teaching. There is, however, limited guidance for teachers concerning how to teach children these competences and adapt their teaching strategies accordingly. It is this lack of knowledge that shaped the rationale for this study. In my research I set out to find out more about the teaching strategies teachers can employ to teach children the competences needed to manage knowledge uncertainty.

Chapter 2 Conceptual framework

> The most inescapable imperative of the future is continuous change, change that involves complex adjustments to the increasingly complex systems that dominate our lives. Therefore, the distinguishing characteristics of those who will not only survive but thrive in the future, will be abilities and traits, both intellectual and emotional, that entail excellence in evaluating and responding to the conditions of change.
>
> Richard Paul (1995, p. xi)

2.1 Introduction

In Chapter 1 I described my main research aim: to better understand how we can teach children in an educational setting the competences needed to handle complex and uncertain knowledge—particularly when confronted with contradictory information. In Section 2.2 I first highlight some of the uncertainty concepts discussed in the literature from the field of education, education for sustainable development, management, psychopathology and psychology. I explain why these concepts are of limited value and a different, more optimistic approach regarding uncertainty in education is called for. In Section 2.3 I propose employing the concept of uncertainty competences in education and describe these competences in-depth. In Section 2.4 I discuss the fact that scholars in the field of education are paying increasingly more attention to the need for learners to develop abilities for coping with uncertainty. Teachers, however, still search for practical suggestions they can apply to improve their teaching of complex and uncertain topics. I discuss how three scholars in particular – Ronald Barnett, Michelle Jordan and Ellen Langer – influenced my study. In Section 2.5 I reflect on the concept of learning environments conducive to the development of uncertainty competences and discuss important characteristics gleaned from the literature. In the concluding section, I present the conceptual framework that I employ to examine teaching strategies for teaching children how to manage uncertain knowledge.

2.2 Uncertainty concepts discussed in the literature

2.2.1 Ambiguity, Uncertainty and Knowledge Uncertainty

Ambiguity

The terms *ambiguity* and *uncertainty* are often used in this thesis and call for further clarification. According to Aarts, Chalker and Weiner (2014), ambiguity refers to "the phenomenon whereby a word, phrase, clause, or sentence has more than one meaning" (p. 21). In other words, ambiguity can refer to anything that can be interpreted in more than one way. As interpreted by Trautmann and Van der Kuilen (2015), an ambiguous situation is one in which a decision needs to be made and there is only unclear or incomplete information about the probability of possible outcomes. This is especially relevant in trying to resolve the sustainability challenges discussed in Chapter 1. Grenier, Barrette and Ladouceur (2005) state that an intolerance of ambiguity refers to an individual experiencing an immediate ambiguous situation as threating, whereas an individual who is intolerant of uncertainty cannot cope with the potential occurrence of a future negative event. Reviewing the literature reveals many context-dependant definitions for uncertainty.

Uncertainty

Four definitions of uncertainty are particularly relevant in the context of this study. Ahsan and Musteen (2011) describe uncertainty as "a condition [or situation] in which one cannot accurately predict the outcome of an event due to lack of information, and therefore cannot insure against it" (p. 203). Jordan and McDaniel (2014b) define uncertainty as "an individual's subjective experience of wondering, doubting, or being unsure about how the future will unfold, what the present means, or how to interpret the past. Uncertainty can pertain to one's self, other individuals, or aspects of the environment" (p. 492). This corresponds with Van Asselt's (2010) description of uncertainty as the complete "set of beliefs or doubts that stems from our limited knowledge of the past and the present (esp. uncertainty due to lack of knowledge) and our inability to predict future events, outcomes and consequences (esp. uncertainty due to variability)" (p. 88). Moore et al. (1990) emphasise that "certainty and uncertainty are attitudes towards representations of reality, rather than reality itself" (p. 726).

In summary, according to these definitions uncertainty can refer to *a situation* in which a lack of knowledge makes it impossible to accurately predict a future event, an individual's *set of beliefs* and his or her *subjective experience* of the uncertain situation, as well as the individual's *attitude towards the representation of the reality* of the uncertain situation. According to scholars such as Funtowicz and Ravetz (1993) and Van Asselt (2010), attitudes towards uncertainty in the fields of science and decision-making have modified over time.

Changing perspectives on uncertainty

For centuries science was seen as the path to truth (Mumford, 2003). The intellectual and philosophical Enlightenment movement that developed during the 17th and 18th centuries in Europe viewed research as a quest for certainty. A key concept developed during this era was that of the scientific method, which is dependent on reasoning and objectivity. Enlightenment thinking coalesced in positivism, which is a philosophical theory emphasising that certain knowledge can only be derived from systematic inquiry, identifying hypotheses, gathering objective evidence and testing theories (Mumford, 2003; Scotland, 2012). According to Van Asselt (2010), uncertainty is considered unscientific. This positivist approach to science dominated the field far into the 20th century.

More recently, in 1972 Weinberg identified what he called *trans-scientific questions*, which are societal questions that cannot be answered unambiguously by employing a positivistic approach. Van Asselt (2010) suggests that the reason these trans-scientific questions are unanswerable is because of inherent uncertainty. Uncertainty in this context is related to practical limitations regarding research experiments, unpredictable human behaviour, unknown future events and the involved actors' differing values and norms. Funtowicz and Ravetz (1990, 1993) writing in the 1990s had a considerable influence on changing the narrative from science as a process of discovering the truth and achieving ever greater certainty of knowledge to a narrative of science as a process of coping with increasing uncertainties. While Weinberg placed dealing with societal questions outside of the scientific field, by stating that science could not answer these uncertain social and policy issues, twenty years later, Funtowicz and Ravetz (1993), suggested the need for a paradigm shift towards *post-*

normal science. In this view, managing "the irreducible uncertainties of knowledge and ethics, and the recognition of different legitimate perspectives and ways of knowing" (p. 754) becomes an acceptable aspect of doing scientific research. This change in perspective, which acknowledges the presence of uncertainty, is crucial in seeking solutions regarding sustainability challenges that are characterised by knowledge uncertainty.

Knowledge uncertainty

Knowledge refers to "facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject" (Oxford Dictionaries, n.d., para. 1). In many situations we are dependent on the knowledge of others for understanding events that are distant from us in place, time and/or comprehension (Wilson, 1983). These information sources function as knowledge authorities. When we are dependent, to whatever degree, on these authorities and therefore on what Wilson calls *second-hand knowledge*, we need to be able to trust that these sources will provide us with reliable information (Andersen, 2004). It also means that we need to develop the ability to assess information and judge the credibility of the knowledge authority. In Chapter 1, I discuss how this study focuses on an individual's or a group's confrontation with uncertain, ambiguous and potentially contradictory information (see Figure 1.1). Understanding the sources of the experienced uncertainty may provide insight into particular skills that can aid the individual in managing the uncertainty.

Sources of knowledge uncertainty

The literature reveals different *sources of uncertainty*. According to Van Asselt (2010), the two main sources or origins of uncertainty are *variability* and *lack of knowledge*. Variability refers to the myriad of ways the system/process can behave, as well as the different values humans ascribe to the system. Lack of knowledge may refer to the individual (researcher) or the current state of scientific knowledge. Gabella (1995) describes two types of uncertainty that seem to correspond with Van Asselt's (2010) sources of uncertainty: "Doubt presented by multiple possible alternatives, and doubt presented by our ignorance of what is to be—uncertainty of the outcomes of inquiry" (p. 237).

Tauritz (2012a) describes a situation in which an eight-year-old child is confronted with contradictory information regarding climate change and has to decide how to act upon the information. The perceived knowledge uncertainty in such a situation could be caused by ambiguous and confounding evidence and/or overly complex information. According to Schulz and Bonawitz (2007), when someone receives confounding evidence, some crucial information is lacking. Knowledge uncertainty can also stem from two other sources: the trustworthiness of the knowledge authority and/or the reliability of the information.

After close reading of the literature I propose a new overview (see Table 2.1 below) which integrates the ideas of several scholars (Gabella, 1995; Langsdale, 2008; Tauritz, 2012a; Van Asselt, 2010). Two main sources of knowledge uncertainty are postulated: *variability* and the *quantity & quality of knowledge*. The first category is very similar to Van Asselt's (2010) first source and bears the same appellation. The second source overlaps with Van Asselt's (2010) source lack of knowledge, yet is broader. First, it acknowledges that too much knowledge is equally able to lead to knowledge uncertainty as too little knowledge. In addition, it incorporates the reliability of the information which can, amongst other things, be influenced on an epistemological level by doubts regarding the best description of reality or on a methodological level by a lack of knowledge regarding the best research methods. Another relevant source is uncertainty stemming from potential untrustworthiness of the knowledge authority.

Variability	Non-linearity and chaotic system behaviour Inherent randomness of nature Unpredictability of human behaviour Diversity of the involved actor's values and norms Social, economic, cultural dynamics or technological surprises
Quantity & quality of knowledge	Unclear which description or model best represents reality Lack of knowledge concerning the right research methods Inexactness (measurement errors) Too few measurements Too much information Simplification of complex data Untrustworthiness of the knowledge authority Irreducible ignorance (e.g. future is unknowable)

Table 2.1: Sources of knowledge uncertainty

A range of uncertainty competences could be brought into play to assist in managing each of the different sources of uncertainty (see Section 1.2.4 and 2.3.3). For example, understanding people with different perspectives may be useful in dealing with uncertainty caused by the conflicting values and norms various actors bring to a sustainability challenge; or being able to assess a knowledge authority's credibility by finding information about their professional background and track record. Some scholars (Langsdale, 2008; Van Asselt, 2010), argue that because of the inherent uncertainty resulting from variability in non-linear and unpredictable systems, no amount of research could lead to complete knowledge about systems of that sort. Van Asselt (2010) points out that more information does not necessarily decrease uncertainty. New information can reveal other previously unknown uncertainties about a complex system. The latter is common with respect to sustainability challenges characterised by complexity and uncertainty. Uncertainty competences from all categories could be of service.

2.2.2 Complex, Supercomplex, Wicked and Super Wicked Challenges

Complex and Supercomplex Challenges

Many scholars (Barnett, 2011, 2012; Camillus, 2008; Conklin, 2001; Conklin, Basadur & VanPatter, 2007; Levin, Cashore, Bernstein & Auld, 2012; Ramaley, 2014; Ritchie, 2011; Rittel & Webber, 1973; Van Asselt, 2010) have formulated their own descriptions of complex issues in an effort to understand these challenges and theorise about effective ways of addressing them. These complex issues are comparable to the sustainability challenges central in my study. Barnett (2012) distinguishes between complex and supercomplex phenomena. He argues that complex problems refer to situations in which the problem could, in principle, be resolved as long as ample time and resources were available. Van Asselt (2010) on the other hand, defines a problem as complex when it concerns multiple intertwined issues which are multidisciplinary in nature and which interact on various scale levels (from local to global) and time lines. The number of complex challenges humanity is facing continues to increase "due to scale-enlargement, globalisation, technological innovation and an increased interconnectedness" (Asselt, 2000, p. 3).

These challenges are further complicated by the number of involved individuals or organisations who bring diverse, sometimes contradictory perspectives, interests, values and needs to the negotiation. Barnett (2012) refers to challenges of this sort as *supercomplex*. The challenges supercomplexity poses can never be entirely resolved because they "produce a multiplication of incompatible differences of interpretation" (Barnett, 2012, p. 67). Van Asselt (2010) speaks of *pluralism* referring to differing legitimate and valid perspectives. New questions keep arising because people view the world through different perspectives, values and sometimes completely incompatible paradigms. Barnett (2011) regards the world as "radically unstable because the very categories by which we relate to the world and through which we seek to understand it are contested" (p. 8). The multitude of perspectives central to sustainability challenges necessitates the development of collaboration and communication skills, as well as the ability and willingness to understand different points of view. The present study demonstrates how important it is for children to learn to understand the language people use to express their degree of certainty and to discern who to trust as the most knowledgeable source (see Chapters 5-8 and Chapter 10).

Wicked challenges

The concept of *wicked problems* is increasingly used to describe sustainability challenges (see Section 1.2.1). Rittel and Webber coined the phrase in 1973 and originally applied it to social and policy planning problems. From examining the characteristics of wicked problems, it becomes evident that sustainability challenges are not *merely* more complex problems, but that they are fundamentally different in nature (Conklin et al., 2007). The central tenet of this thesis is that being able to manage these problems can be supported by the development of uncertainty competences (See Section 2.3).

Wicked problems are often contrasted with *tame problems*. Ritchey (2011) describes tame problems as relatively well-defined issues that can be solved in a manner comparable to similar problems that have already been successfully dealt with. Potential solutions can be tested and rejected. There are clear objective criteria to assess if a satisfactory solution has been achieved. Wicked problems on the other hand, are ill-defined and ambiguous problems which, according to Ritchie (2013), are "associated with strong moral, political and professional issues" (p. 2). Ramaley (2014) writes that these problems revolve around contested questions and Camillus (2008) adds that they have innumerable causes. No wicked problem is ever exactly the same as another wicked problem. Decision-makers require the ability to use the uncertainty that stems from the nature of these problems in a creative manner. Multiple stakeholders are involved and although resolving the issue is dependent on these stakeholders (Ritchey, 2011), full agreement even on something so basic as the problem definition is practically inconceivable (Camillus, 2008). This is particularly relevant as each potential solution is dependent on the employed definition. In addition, Ritchie (2013) proposes that to be able to provide a detailed description of a wicked problem, a complete list of potential solutions is needed at the beginning rather than the end of the planning process. This unconventional order requires a flexible mind-set and being able to think laterally – both of which are abilities that are among the uncertainty competences discussed in this thesis (see Section 2.3.3).

What also makes dealing with wicked problems so challenging, is the fact that they won't 'keep still'. Ritchie (2013) explains that they are "complex, interacting issues evolving in a dynamic social context" (p. 2). Additionally, new wicked problems often surface in response to an attempt at understanding and resolving an existing wicked problem. Scholars (Camillus, 2008; Ritchie, 2013) argue that resolving wicked problems requires novel ways of thinking as they cannot be treated successfully with more conventional, linear, analytical approaches. Camillus (2008) warns that "not only do conventional processes fail to tackle wicked problems, but they may exacerbate situations by generating undesirable consequences" (p. 100). The *slippery nature* of wicked problems demands the ability to work in an ever-changing and therefore inherently uncertain setting. Furthermore, Ritchie (2011) points out that future events cannot always be visualised, categorised and predicted, as many developments along the way will be a result of emergent processes. The uncertainty resulting from these processes cannot be resolved by simply gathering more information because the required information does not yet exist. In accordance with Conklin (2001), I suggest that dealing with wicked problems requires people to make use of opportunities, take bold action, experiment and make decisions in the face of uncertainty.

Wicked problems are known for not having one obviously right answer. On the contrary, Ramaley (2014) notes that solutions are often disputed and a complete solution is never achieved, as the problem continues to develop and change over time. This requires decision makers willing to learn, and able to collaborate and tolerate uncertainty. Camillus (2008) suggests that the stakeholders need to create a shared understanding of the problem. He explains that this involves not only the ability of the stakeholders to communicate what they are thinking about the problem and to understand what others are communicating about their views, but also the need to cultivate the willingness to work together in tackling these challenges. I will return to this issue in Chapter 6 where I discuss two uncertainty competences that specifically deal with communicating about the certainty of knowledge.

Rather than agreeing that the problem has been solved satisfactorily, efforts to find a solution for a wicked problem may be terminated on the basis of such practicalities as running out of money or time. It is difficult to label a solution as good or bad, satisfactory or unsatisfactory as it depends on all the involved stakeholders' points of view. In addition to not having unambiguous end-criteria, it is hard to even tell when a wicked problem has been resolved, as solutions to wicked problems create consequences that continue to have influence over extended periods of time. Each implemented solution yields consequences, positive or negative, and of varying degrees of seriousness. Undesired or unanticipated outcomes can pose new wicked problems that then have to be dealt with in their own right. It is also impossible to know with 100% certainty that all resolutions to a wicked problem have been identified. Each wicked problem can be viewed as the symptom of some other problem, and there are many causal levels that need to be examined. An often-cited example of a wicked problem is poverty. Poverty is multidimensional and is situated in a dynamic social context. It relates to many issues such as employment, income, education, health, and nutrition. This makes it hard to define and hard to solve. Many stakeholders are involved ranging from the poverty stricken individual to the government, potential employers, healthcare professionals, and educators. There is no one single right solution.

Super wicked challenges

Some authors like Levin et al. (2012) differentiate between wicked and super wicked problems. According to them, what distinguishes super wicked problems, such as global warming, overfishing and plastic pollution from wicked problems are four key features. The first is the urgency of addressing these problems, in consideration of the possibility that the time to address them may be running out. In the case of global warming, for example, some places and the people living there are already confronted with its devastating effects. Secondly, some of the people responsible for the problem are also among those seeking to resolve it. Thirdly, the central authority required for solving the challenge is weak or non-existent. Fourthly, of those responsible for finding solutions, many do not take seriously the task of dealing with the problem, preferring to leave this for future generations to deal with.

Section 2.2.2 described the nature of the uncertainty that permeates sustainability challenges. Decision-makers cannot avoid this uncertainty when attempting to resolve these challenges. But how willing and capable are people of addressing these challenges in constructive ways? The literature describes a variety of concepts related to people's ability and willingness to manage uncertainty, for example, *cognitive dissonance, cognitive disequilibrium*, *intolerance of uncertainty*, *intolerance of ambiguity* and *uncertainty orientation*. I briefly reflect on each of these concepts in Sections 2.2.3 to 2.2.5.

2.2.3 Cognitive dissonance and cognitive disequilibrium

Cognitive dissonance

In 1957, Festinger coined the now well-established term *cognitive dissonance* to describe a concept which outlines the ways in which people manage inconsistencies between their cognitions (e.g. ideas, beliefs, values, emotional reactions). Cognitions can be unrelated, related and in agreement, or related and contradictory. In dealing with sustainability challenges, new and often complex, uncertain and contradictory scientific information is frequently encountered. This can induce uncomfortable levels of uncertainty (Bradshaw & Borchers, 2000). When an individual is confronted with too much new, uncertain and sometimes even threatening information, for example, with regard to global climate change, feelings of being overwhelmed can arise. Cognitive dissonance occurs when an individual is confronted by conflicting cognitions. Another way to describe this state is to say that the conflicting cognitions result in uncertainty as to which cognition is correct. A dissonant state is uncomfortable and individuals are therefore motivated to reduce dissonance and "maintain consistency between their beliefs, actions and behaviours" (Brown, 2008, p. 7) by altering existing cognitions (i.e. changing one's interpretation of an event) or adding new ones to create consonance. According to this model, potentially dissonant knowledge is thereafter avoided.

Cognitive disequilibrium, assimilation and accommodation

Three well-known and closely related concepts postulated by psychologist Piaget have been applied in the field of education and are worth noting: *assimilation*, *accommodation* and *cognitive disequilibrium*. According to Piaget (1952), when new information is similar to and consistent with an individual's prior knowledge and behaviour, it can be easily accepted and integrated into existing cognitive structures;

this process is known as assimilation. However, when information cannot be related to earlier held beliefs and ideas, existing cognitive structures have to be modified in order for the information to be integrated; Piaget (1952, 1954) calls this process accommodation. Cognitive disequilibrium refers to the internal conflicts a child experiences when differences exist between current cognitions and new information; disequilibrium is an important aspect of the learning process (Piaget, 1952). This conceptualization, in contrast to Festinger's, suggests a more positive view of dissonance. Stonewater and Stonewater (1984) go on to explain that the experience of disequilibrium is a prerequisite for cognitive development. They further elucidate that teachers need to actively facilitate this process by implementing teaching strategies that create a degree of disequilibrium that is carefully adapted to the children's developmental stage. In addition, they state that teachers should be offering a sufficient degree of psychological support for potential feelings of anxiety rendered by the experienced disequilibrium. Piaget's observations in the context of the education of children supported my own surmises about the value of uncertainty in the classroom.

2.2.4 Intolerance of uncertainty and intolerance of ambiguity

The concept *intolerance of uncertainty* is regularly utilised in the field of clinical psychology. The related literature typically focuses on matters such as psychopathology, anxiety disorders, health-related anxieties and stress (Rosen, Ivanova & Knäuper, 2014). It describes a tendency to react negatively on an emotional, cognitive, and behavioural level to uncertain situations and events as a result of negative beliefs and assumptions held regarding uncertainty (Rosen et al., 2014). Individuals with a low tolerance for uncertainty characteristically find *not knowing* distressing and have difficulty functioning in uncertain situations (Comer, Roy, Furr, Gotimer, Beidas, Dug's & Kendall, 2009). This poses serious issues concerning such individuals' abilities to manage sustainability challenges. Similarly, in the management literature, researchers employ the concept *intolerance of ambiguity*. This term relates to the tendency of individuals who cannot adequately handle ambiguous situations to experience them as threatening and uncomfortable (Rosen et al., 2014). Individuals who are intolerant of uncertainty find it unacceptable that a negative situation might occur in the future (Grenier et al., 2005). They lack uncertainty competences such as being able to accept not knowing what will happen, and the ability to use uncertainty in a positive and creative manner. Both concepts – intolerance of ambiguity and intolerance of uncertainty – ignore uncertainty's potentially positive qualities to foster innovation and promote learning (Jordan & McDaniel, 2014b).

2.2.5 Uncertainty orientation

Sorrentino and Roney (2000) developed the concept *uncertainty orientation* to describe the way in which people cope with uncertainty. They demonstrated that individuals can be found along a continuum. At either end there are those considered to be uncertainty-oriented individuals (UOs) or certainty-oriented individuals (COs). Those described as UOs prefer handling uncertainty by searching for information and actively resolving the uncertainty. In contrast, COs are more comfortable with a self-regulatory style that evades uncertainty. According to Szeto and Sorrentino (2010) these individuals "…would rather live in a world that is consistent and stable, devoid of any opportunities for confusion or ambiguity" (p. 149). If given a choice they will focus on activities that help them maintain clarity. When confronted with uncertainty they utilise other people or heuristic concepts to reduce the uncertainty (Sorrentino et al., 2003). In short, UOs find uncertainty a challenge and COs find uncertainty something that should be avoided. With respect to handling sustainability challenges, it seems obvious that UOs will be much more willing and able to deal with these wicked challenges than COs. Such a dichotomy is also visible in the classroom where, according to Huber, Sorrentino, Davidson, Eppler and Roth (1992), UOs are much better at doing collaborative work and performing learning activities focused on self-discovery than COs. The latter prefer teachers to provide the right answer. However, while positioning individuals along a continuum of uncertainty orientations is insightful, it may be too simplistic in its representation of reality. It disregards many factors influencing an individual's response to uncertainty at a particular moment in time, such as their previous experience and prior knowledge about the subject or the social relations between the actors.

Section 2.2.2 highlights how taxing and demanding managing sustainability challenges can be with respect to the uncertainty and complexity that characterises wicked problems. Dealing with them requires competences that reach beyond the 21st century skills and critical thinking skills discussed in Chapter 1. The uncertainty concepts discussed in Section 2.2.3 are, however, of limited value in their use for understanding how teachers can facilitate the development of the ability and willingness to engage with sustainability challenges filled with uncertainty and contradiction. In the next Section, I discuss the need for developing specific competences that could help individuals both to cope better with and even to thrive when confronted with uncertainty.

2.3 Uncertainty competences

Barnett (2012) asks a very significant question: "If the future is unknown, what kind of learning is appropriate for it?" In Section 2.3.1 I examine what scholars have said about the concept of *competence* and will provide the definition that I employ in the present study. Competences that scholars deem necessary for the particular resolution of sustainability challenges will be addressed in Section 2.3.2. In Section 2.3.3 I focus specifically on uncertainty competences, offer a general definition, and operationalise individual competences.

2.3.1 Competence development: Teaching beyond content-knowledge

An increasing number of contemporary scholars assert that acquiring content knowledge is not enough to survive and thrive in today's society, which can be characterised by information overload, dynamic and unstable systems, and unprecedented levels of uncertainty (Barnett, 2012; Buckingham Shum & Deakin Crick, 2012; Klieme, Hartig & Rauch, 2008). In order to handle our complex and uncertain world, it is arguable that learners need to develop abilities, skills and learning dispositions in addition to content-knowledge. However, scholars such as Barnett (2012) emphasise that as we don't yet know which knowledge and skills we will need, it is imperative to develop "human qualities and dispositions" (p. 65). Our knowledge, for example with regard to sustainability challenges, is in a constant state of flux. It therefore follows that learners need to become *life-long learners* who can and want to acquire new knowledge as it becomes available in order to apply it creatively as they encounter future events. Others variously describe the need for:

- “Propensities for managing uncertainty” (Jordan, 2015, p. 99)
- “Ability to creatively and spontaneously use uncertain information” (Langer, Hatem, Joss & Howell, 1989, p. 147)
- “The ability to analyse, evaluate and craft rich pictures of the future” (Wiek, Withycombe & Redman, 2011, p. 207-209)
- “Strategies and skills for dealing with uncertainty” (Hall, 2010, p. 165)
- “Reflective thinking skills” (English, 2013, p. 94)
- “Capabilities—the ability to adapt to change, to generate new knowledge, and continuously improve one’s performance” (Fraser & Greenhalgh, 2001, p. 799)
- “Critical thinking skills and moral fortitude” (Gordon, 2006, p. 21)
- “Integrated thinking, problem solving, and personal and social skills” (Higgins, 2001, p. 101)
- “An authentic identity, a capacity to choose from conflicting evidence and preparedness to revise in light of new insights” (Kreber, 2009, p. 15)
- “Dispositions and forms of being that will allow them to face the challenges of a future marked by uncertainty” (Anderson & McCune, 2013, p. 155)
- “Actively anticipating and engaging with sustainability futures” (Gardiner, 2017, p. 251)

As the list above demonstrates, scholars use a host of words to describe the attributes learners need to develop: propensities, abilities, strategies, skills, capabilities, moral fortitude, authentic identity, dispositions, competences, and so on. This can become confusing. I will define *competence* as it is employed in this study in detail. Before that, however, I first examine some descriptions and definitions others have employed, and that have been constructive in forming my own understanding of competences. It is important to remember that the focus of this thesis is the upper primary school context and that my definition has been formulated with this in mind.

Competence consists of attributes

To begin with, scholars employ different words for the components of a competence. For example, Gardiner (2017) talks about “cognitive, emotional and social prerequisites for successful action” (p. 244), Mulder (2016) speaks of “characteristics which enable performance” (p. 18), and Klieme et al. (2008) write about “context-specific *cognitive* dispositions" (p. 9). I found Rychen and Salganik's (2003) description of the "internal structure of a competence" (p. 44), in which they discern a set of attributes, particularly helpful. From here on in this thesis, I employ the term *attribute* when referring to the components of a competence.

A range of attributes constituting core competences are mentioned in the literature: generic capabilities (Mulder, 2016); performance-oriented capabilities, cognitive-, interactive-, affective- and psychomotor capabilities (Biemans, Nieuwenhuis, Poell, Mulder & Wesselink, 2004); psycho-social components (Barth, Godemann, Rieckmann & Stoltenberg, 2007); knowledge, skills, attitudes (Mulder, 2016; Rychen & Salganik, 2003, UNESCO, 2015; Wiek et al.,2015); cognitive skills, practical skills, (learning) dispositions, emotions, motivation, desires, values and ethics (Biemans et al., 2004; Buckingham Shum & Deakin, 2012; Rychen & Salganik, 2003); strategies (Tauritz, 2016), a sense of agency (Hoskins & Crick, 2010), and resources embedded in the individual (Rychen & Salganik, 2003). In my study I consider the internal structure of a competence to consist of a varying composition of the following attributes: knowledge; cognitive-, practical-, social- and communication skills; strategies; dispositions; motivation; and values. Crucially, according to this paradigm, an individual does not either possess a competence or not; competences exist on continua. Many competences can be developed and further refined through teaching and learning. Furthermore, possessing a competence implies that an individual not only has the knowledge, skills and motivation to take action or make a decision, but is also able to apply the competences in the right setting and at the appropriate time as suggested by Rychen and Salganik (2003).

Competence is contextual

Scholars emphasise that competence should be understood as the ability to take effective action (Barth et al., 2007; Buckingham Shum & Deakin, 2012), cope with concrete situations or tasks (Klieme et al., 2008), or meet complex demands in a particular (professional) domain or organisation (Biemans et al., 2004; Rychen & Salganik, 2003). In addition, Rychen and Salganik (2003) maintain that a "competence is a product of the interaction of attributes of individuals and the context in which they operate …" (p. 46). An individual's competences are manifested in his actions, behaviours and decisions in specific situations. Similarly, Hoskins and Crick (2010) describe a competence in terms of “effective, embodied human action in the world in a particular domain” (p. 122). Actions typically take place in social fields such as the political field, the field of work, family life and the classroom. Oates (2003) broaches another important issue when he questions if one can really speak of the transfer of skills, or if in reality this always implies a form of adaptation. The concept of transfer suggests that an individual who is competent in one context can draw on his or her experience and the same competences in similar situations. However, the situations we face will never be exactly the same. Therefore, Rychen and Salganik (2003) speak in preference of *adaptation*, which entails actively and reflectively using the knowledge, skills, or strategies one developed in one situation and translating and adapting them to the new situation. Acknowledging the importance of the transference factor has implications for education. It should be noted that there are critics such as Stenhouse (1975) who warn against basing a curriculum entirely on pre-specified learning objectives. Such an approach they advise might be useful for teaching factual knowledge and simple skills, but it is less appropriate for the development of complex skills, values and dispositions. More recently Morcke, Dornan and Eika (2013) have stressed the need for further research focusing on how education based on pre-specified outcomes works, and when and for whom it is or is not useful. The present study contributes to a more inclusive understanding of competency-based education. Stenhouse (1976) posited that a reductionist competency-based approach focusing mainly on predetermined learning outcomes is not appropriate for teaching and understanding complex and uncertain knowledge. In 1975 he warned that specifying these predetermined learning outcomes with respect to gaining knowledge may limit (children’s) genuine inquiry.

Definition of competence

In this study I define *competence* as the ability to effectively mobilise attributes such as knowledge, (cognitive, practical, social and communication) skills, strategies and dispositions, in order to make effective performance possible. Competence also encompasses motivation and values, as well as the ability to mobilise all of the above attributes in the right place and at the right time in order to take effective decisions and actions in specific situations. This broad definition of a competence addresses criticisms that have been made with respect to competency-based education. It does not limit itself to skills needed to meet complex demands in specific situations, a description Lozano, Boni, Peris and Hueso (2012) provide for competency-based education. In addition, my definition does not limit itself to those skills or attributes that are more easily measurable, a critique offered by Holmboe, Sherbino, Englander, Snell and Frank (2017). As I noted earlier, meeting sustainability challenges is uniquely demanding and requires a variety of specific competences. Before focusing in on the concept of uncertainty competences in Section 2.3.2, I will first discuss the sets of competences that some scholars feel are essential in dealing with complex sustainability issues (De Haan, 2010; Gardiner, 2017; Wiek et al., 2015).

2.3.2 Sustainability competences

Various scholars have debated which mixture of competences people need to be able to effectively resolve sustainability challenges; they are often referred to as ‘sustainability competences’ and can be seen as, according to Gardiner (2017), the ability to actively anticipate and engage with a sustainable future. Gardiner and Rieckmann (2015) point out that while some scholars focus on the mixture of competences that decision-makers, planners, policy makers and managers need for solving sustainability challenges (e.g. Wiek et al., 2011), others see sustainability competences specifically as something that all graduate students need to acquire (Rieckmann, 2012). Wals and Lenglet (2016) take a broader view: they are of the opinion that all citizens need to transform into ‘sustainability citizens’ in order to participate more fully in, and contribute to a sustainable society. Below is a brief discussion of the four sustainability competence models that had a significant influence on my thinking regarding uncertainty competences.

1. Dimensions of sustainability competence and associated sustain‘abilities’

Wals and Lenglet (2016) discuss, without trying to be exhaustive, four dimensions of sustainability competences: “conceptual and systemic knowledge, critical thinking, change and innovation and ethical or existential, normative dimension” (p. 55). For each dimension they indicate some abilities that a sustainable citizen should develop, for example, systems thinking, questioning hegemony and routines, appreciating chaos and complexity, and unlocking creativity. No direct mention, however, is made regarding the management of uncertainty. While these competences were of clear relevance, the model Wiek et al. (2015) provided was operationalised in much more detail.

2. Key competencies for sustainability researchers and problem solvers

Wiek et al. (2011) propose a framework consisting of six key competences. These competences are meant to enable the individual to effectively solve real-world sustainability challenges. Wiek et al. (2015) operationalised these competences in great detail and with graduate education in mind. According to the authors, competent students understand and can apply system dynamics, cross boundaries between different domains and at different scales, anticipate and construct rich pictures of a sustainable future. In addition, being competent involves the ability to evaluate and negotiate sustainability values, principles and goals. The graduate should also be able to design and test systemic interventions, mobilise resources, involve stakeholders and ultimately carry out plans to resolve sustainability challenges. Further attention is paid to the ability to facilitate collaboration with team members and stakeholder engagement. This last competence can be summarised as a *meta-competence*, which is the ability to employ and purposefully integrate the other five key competences in order to resolve sustainability challenges and foster sustainable development. Wiek et al. (2015) do mention concepts such as complexity, non-linearity and probability, but do not specifically mention dealing with uncertainty or ambiguity. De Haan, below, discusses competences in terms more easily translatable to a wider range of learners.

3. Gestaltungskompetenz

De Haan (2010) coined the concept of *Gestaltungskompetenz*, which is another formulation of sustainability competence. He states that those “who possess this competence can help, through active participation, to modify and shape the future of society, and to guide its social, economic, technological and ecological changes along the lines of sustainable development” (p.320). Gestaltungskompetenz can be split into twelve sub-competencies (De Haan, 2010). Some examples include the ability to acquire knowledge and act in an interdisciplinary manner, cope with individual dilemmatic situation of decision-making, and deal with incomplete and overly complex information. The latter is the most relevant to my study. De Haan (2010) does not, however, mention uncertainty or ambiguity as such. The final framework that I will discuss, ESD Competencies Framework, addresses issues of uncertainty.

4. ESD Competencies Framework

Mochizuki and Bryan (2015) describe extensively the kinds of knowledge, skills and dispositions they think learners need to acquire within the context of climate change education (See Section 2.4.1). They distinguish between (1) “Learning to know: Understanding the causes and consequences of climate change” (p.16); (2) “Learning to do: Transversal/cross-cutting skills” (p.18); and (3) “Learning to live together and learning to be: Global citizenship education and CCESD[12]” (p.21). The authors specifically mention the need for abilities related to managing uncertainty. In the first category they talk about enabling students to distinguish between certainty, uncertainty and risks associated with climate change. In the second category they mention being able to handle rapid change, complexity, insecurity and uncertainties and understand differences in worldview on sustainable development. Mochizuki and Bryan (2015) also recognise the importance of teaching people the abilities to cope with the emotional impact of climate change.

In reviewing what scholars had said about teaching competences needed for the management of uncertainty, I examined multiple sustainability frameworks. Some did not mention anything about handling uncertainty at all (Wals & Lenglet, 2016), some considered related concepts such as complexity, non-linearity and probability and making decisions with incomplete information (De Haan, 2010; Wiek et al., 2011; Wiek et al., 2015) and others such as Mochizuki and Bryan (2015) specifically discussed coping with uncertainty. Some frameworks were developed with teaching sustainability competences in mind (De Haan, 2010; Mochizuki & Bryan, 2015) and others featured more general reflections on what abilities citizens need in order for the development of a more sustainable society to take place (Wals & Lenglet, 2016).

[12] During the second half of the UN Decade of Education for Sustainability, UNESCO launched the ‘Climate Change Education for Sustainable Development’ programme (CCESD) (Mochizuki and Bryan, 2015).

.

Frameworks designed to teach about a particular topic, such as Mochizuki and Bryan's (2015) framework for teaching about climate change, often include competences not directly related to managing uncertainty, for example technical knowledge about climate change and the awareness and willingness to accept one's culpability in complex sustainability issues regarding consumer behaviour. Such a framework, in which the only uncertainty dealt with is knowledge uncertainty directly related to sustainability or climate change, is less suitable for a study focussing explicitly on uncertainty and ambiguity. The above frameworks are certainly relevant for a study concerning teaching how to manage uncertainty with respect to sustainability challenges. However, in relation to primary school education managing knowledge uncertainty is a concept that has a broader significance. Even though the above described sustainability frameworks contributed to my thinking, none were entirely appropriate with respect to my research regarding teaching primary school children how to manage uncertainty in an educational context.

The focus of my research and my conceptual framework thus evolved as a direct consequence of the lack of studies that specifically address teaching the competences needed to deal with uncertainty in primary school education. In the next section I will discuss my conceptualisation of uncertainty competences.

2.3.3 Three categories of uncertainty competences

In Section 2.3.1 I outlined the myriad of definitions I found related to core competences needed to take effective decisions and actions in specific situations. In addition, I described the most relevant of the sets of competences scholars have suggested individuals need to possess to manage sustainability challenges. In this study I focus on one particular component of sustainability as well as many other challenges: uncertainty. In earlier work I developed an extensive literature-based list of competences needed to handle knowledge uncertainty (Tauritz, 2012a, 2016). I used it as a guide during the initial stage of the data analysis phase, after which the list was further refined, and additional uncertainty competences emerged. They will be discussed in Chapter 6. The full definition of the umbrella term uncertainty competences employed in this study is as follows.

Uncertainty competences encompass the knowledge, cognitive, practical, social and communication skills, strategies, dispositions, motivation, values, as well as the ability to mobilise these attributes in the right place and at the right time in order to take effective decisions and actions when faced with knowledge uncertainty.

In this section I will focus on my previously established uncertainty competences (Tauritz, 2016, see Table 2.2). By organising the competences into three categories it is my intention to emphasise that learning how to manage uncertainty involves not only learning how to reduce uncertainty, but also accepting that it may not be possible to eliminate all uncertainty. That being the case, learning how to be comfortable when faced with uncertainty in order to respond effectively becomes an important strategy for dealing with complex sustainability challenges. However, I suggest that it is imperative to also learn how to cherish uncertainty. The new paradigm that I and many other scholars (Barnett, 2012; Brown & Beames, 2017; English, 2013; Floden & Buchmann, 1993; Forrest et al., 2012; Fraser & Greenhalgh, 2001; Gabella, 1995; Gordon, 2006; Higgins, 2001; Jordan, 2015; Langer, 2014) propose is one in which uncertainty and complexity are valued and actively invited into the learning environment where they are seen as fundamental driving forces in teaching. Cherishing uncertainty requires a profound change in perspective. Until recently in society in general, and in education in particular, uncertainty, ambiguity and complexity have typically been viewed as something to be avoided and eliminated in the interest of clarity and efficiency (Higgins, 2001; Visser, 2004). However, the attempt to avoid something as ubiquitous as uncertainty can only result in inevitable failure. In addition, is uncertainty necessarily negative? Uncertainty can become an invitation to let go of the obvious and create new understandings (Langer et al., 1989; Tauritz, 2016). The unknown need not be perceived as something to fear as long as tools to deal with it are available. In that case, it can be a catalyst for creative action and curiosity. The uncertainty competences in the first category are designed with this in mind. The list reveals how broad the range of competences needed to manage uncertain knowledge is and how the more familiar competences, for example, regarding information literacy, relate to managing uncertainty. In the rest of this section uncertainty competences are operationalised.

Learning to cherish uncertainty
1. Being able to use uncertainty as a catalyst for creative action
2. Being able to empathise with people with different perspectives
3. Being able to ‘entertain’ an enquiring mind
Learning to tolerate uncertainty
4. Being able to accept not knowing what will happen
5. Being able to reflect on and change one’s beliefs regarding uncertainty
6. Being able to employ lateral thinking
Learning to reduce uncertainty
7. Being able to prioritise (‘triage’) among many urgent issues
8. Being able to find, evaluate and utilise information (specific knowledge)
9. Being able to judge the credibility & cognitive authority of information sources
10. Being able to reason (inductive and deductive reasoning)
11. Being able to respond in accordance with the underlying probabilities
12. Being able to employ previous experience
13. Being able to assess one’s own ability to achieve a desired outcome
14. Being able to engage a supportive network
15. Being able to formulate a plan of action to deal with uncertainty
16. Being able to work in, and contribute to, teams with mixed skills and experience
17. Being able to use one’s intuition as a source of information

Table 2.2: Uncertainty competences (Tauritz, 2016)

Category: Learning to cherish uncertainty

The three competences in the first category *Learning to cherish* uncertainty emphasise that knowledge uncertainty is not something that always needs to be reduced, or merely tolerated, but is also something that can be embraced. Uncertainty and ambiguity can be viewed as opportunities to be inquisitive and creative. I will briefly explain each competence.

1. Being able to use uncertainty as a catalyst for creative action

An individual who is competent at employing uncertainty as a catalyst for creative action is able to create novel approaches to problem-solving when faced with a complex and uncertain situation with no obvious right solution, and subsequently act decisively and employ the new approach. Not knowing the right solution can be paralysing for some, while others feel energised and see it as a chance to create an innovative solution rather than the solution dictated by previously held ideas and thought patterns (Langer & Moldoveanu, 2000). Jordan and McDaniel (2014a) point out how important it is for students to develop their creativity and improvisation skills in response to a changing world in order to either come with innovative ideas or recombine existing elements in a way that allows new conceptualisations to emerge. This competence goes beyond merely theorising about novel approaches to problem-solving; it is about being able to turn those ideas into actions with the aim of managing the encountered uncertainty.

2. Being able to empathise people with different perspectives

An individual who is competent at understanding people with different perspectives is able to acknowledge, even seek out other viewpoints, articulate and evaluate the differences in points of view, and approach a challenge with a "richness of vision and appropriately broad point of view" (Paul, 1995, p. 160). Such an individual is willing to look at a situation from someone else's perspective and to be respectful of, and empathise with, someone holding an opinion incompatible with their own. Because of the complexity of sustainability challenges, it is essential that decision-makers be able and willing to develop a sufficiently broad outlook based on a wide range of perspectives regarding the issue. I agree with Stenhouse (1976) who suggested that it is important for a teacher to accept controversy and focus on developing the learner's understanding of the differing perspectives regarding an issue rather than aiming for the achievement of consensus and thereby eliminating uncertainty. In other words, pluralism and thus uncertainty, should be valued over quick decision-making (Rudduck, 1988).

3. *Being able to entertain an enquiring mind*

An individual who is competent at *entertaining* an enquiring mind is able to remain inquisitive and open-minded and cultivate a positive disposition towards life-long learning. In Dewey's (1910) words: "… when the child continues to entertain [problems] in his own mind and to be alert for whatever will help answer it, curiosity has become a positive intellectual force" (p. 33). Such an individual questions new information even when obtained from trusted knowledge sources and weighs the merits of new ideas.

Category: Learning to tolerate uncertainty

The three competences in the second category *Learning to tolerate uncertainty* comprise a close weave of skills and dispositions. Letting go of the continuous need for certainty even for a limited time, the ability to adapt to change, strong reflective skills and openness to differing perspectives are central to learning to tolerate uncertainty.

4. Being able to accept not knowing what will happen

An individual who is competent in this respect is able to accept that one can never know with 100% certainty what will take place or what the right answer or action should be in a particular situation. An essential element of this competence is being able to cope with the emotions experienced when confronted with uncertainty. This competence encompasses both cognitive as well as affective elements. It is a broadly defined skill exemplifying how the theory of uncertainty competence development presented in this thesis addresses some of the criticisms made regarding competency-based education. The UO individuals described in Section 2.2.5 have uncertainty-oriented dispositions and feel (more) comfortable than others when faced with uncertainty, ambiguity and inconsistent information. It follows that they will be less hesitant at taking action (Sorrentino & Roney, 2000).

5. Being able to reflect on and change one's beliefs regarding uncertainty

Individuals who are competent at reflecting on personal beliefs regarding uncertainty are able to question their assumptions, handle the discomfort and uncertainty that can arise from questioning one's cherished beliefs (Boler, 1999), decide if an assumption is useful when faced with uncertainty, and has the ability to choose to hold onto or let go of that belief. Certain beliefs may facilitate a positive disposition regarding uncertain situations, for example, viewing a situation where no definitive decision has been taken as an opportunity to be creative and to pursue new ideas. We are not usually aware that our beliefs influence our experiences and that actively changing our beliefs can change those experiences. Understanding the power of belief-making (Gelatt, 1989) and maintaining a flexible mind set are important skills supporting complex decision-making.

6. *Being able to employ lateral thinking*

An individual who is competent at lateral thinking is able to recognise dominant polarising ideas, search for alternative ways of viewing things, let go of (some) of the rigid control imposed by vertical thinking and make better use of chance (De Bono, 1971). According to De Bono (1990), vertical thinking is the *modus operandi* of thinking and is characterised by taking sequential steps that can each be justified, as well as by focusing on what is considered to be relevant information. Lateral thinking on the other hand, involves a deliberate strategy of interrupting the sequentiality of vertical thinking, thus seeking out seemingly unrelated information in an effort to widen the range of potential solutions for a particular problem (The Pfeiffer Library, n.d.). This widening of thought patterns can lead to new insights and creativity. Lateral thinking requires individuals to be able to employ previous experience, and be willing to try out a variety of solutions, recombine ideas with other ideas, and use their imagination. While education has generally focused, at least until recently, on vertical thinking, both thinking strategies are necessary and complementary.

Category: Learning to reduce uncertainty

The eleven competences in the third and last category *Learning to reduce uncertainty* all support the individual in reducing knowledge uncertainty by, for example, gathering and evaluating information, assessing the urgency, reasoning, and working in teams to resolve problems. These competences often relate to critical thinking skills

(Paul, 1995). Teaching to reduce uncertainty both in terms of content and technique is very common in educational practice.

7. Being able to prioritise (‘triage’) among many urgent issues

An individual who is competent at prioritising among urgent issues is able to establish an overview of the most pressing issues, evaluate the consequences of responding or not (yet) responding, and take a decision on how to act responsibly (Tauritz, 2016). Sustainability issues form perhaps the ultimate challenge when it comes to prioritising among urgent issues, as they are by their nature so complex and our knowledge is generally incomplete and contested. Not only don’t we know exactly what the *factual* consequences will be of prioritising one issue above another, but, because of the different values, needs and understanding of the multiple actors involved, it is also generally impossible to come to an unambiguous and incontestable judgment.

8. Being able to find, evaluate and utilise information (specific knowledge)

An individual who is competent at finding, evaluating and utilising information is able to gather essential information, critically assess its accuracy, comprehensiveness and currency to come to a decision based on that information (Metzger & Flanagin, 2013). It should be noted, however, that finding information, as well as other competences in this category do have the potential to increase uncertainty as well as reduce it. New questions can emerge as information is gathered. Therefore, as exemplified by confrontation with sustainability challenges, it is important for individuals to possess information search skills and strategies and have the ability to assess whether obtained information is sufficient to solve their problem. Another related skill is being able to delay interpreting ambiguous information in order to gather disambiguating evidence (Beck et al., 2008). Jordan and McDaniel (2014b) mention other methods for gathering information as well, for example, systematic testing and trial-and error experimentation; others have mentioned relevant cognitive processes that need to be developed such as analysing and interpreting data (Bloom, Engelhan, Furst, Hill & Krathwohl, 1956; Krathwohl, 2002). Further discussion concerning finding information and conducting research can be found in Chapter 10.

9. Being able to judge the credibility and cognitive authority of information sources

An individual who is competent at judging the credibility and cognitive authority of information sources is able to question the trustworthiness of the information source, understand what the source based its conclusion on, and recognise any interests and (hidden) goals the source may have had in sharing the information. The importance of the ability to assess knowledge sources is recognised by many scholars (Bråten, Strømsø & Salmerón, 2011; Ennis, 1985; Hobbs, 2017; Paul, 1995; Tauritz, 2016), yet in practice there is still much concern about the lack of these skills in both children and adults (Julien & Barker, 2009; Hobbs, 2017).

10. Being able to reason (inductive and deductive reasoning)

An individual who is competent at reasoning is able to draw a conclusion or inference through deliberate and careful thought, reflection and observation of facts or hypotheses (Paul, 1995). The individual can articulate her assumptions, inferences and arguments clearly and base decisions on, for example, deductive, inductive or abductive reasoning (See Section 3.2.3 for more information about the reasoning process). Van Gelder (2005) explains that humans are pattern-seeking beings; humans like things to make sense and often will stick with a story that intuitively seems right without further investigation. Critical thinking and developing one's reasoning skills in a wide range of context requires practice.

11. Being able to respond in accordance with the underlying probabilities

An individual who is competent at responding in accordance with the underlying probabilities is able to assess the probability that a given event will or will not take place and assess how certain the information source is of the information being shared. Understanding probabilities involves both a mathematical understanding as well as an understanding of the language used to communicate about probabilities (See Chapter 6). Gregory (1991) explains that individuals who have only a vague mathematical notion of probability are less able to consider the consequences of alternative choices, potentially causing their decision-making to suffer. They will also be more likely to fall prey to well-known biases, such as viewing probabilities with a high likelihood as more certain and events with a low probability as less certain than they actually are.

Van Asselt (2010) points out that the decision-making process is not always improved by an accumulation of additional knowledge and that, instead, decision-makers often need support with understanding probabilities and the associated uncertainty.

12. Being able to employ previous experience

An individual who is competent at employing previous experience is able to adapt previously acquired knowledge and skills to new contexts; this could speed up the learning process and the process of taking action when faced with uncertainty. On the other hand, focusing on previous experiences can also potentially hinder creativity and the discovery of novel solutions. The individual needs to be flexible in using previous experience and know when to tap into that knowledge and when to take, for example, a lateral thinking approach (see Learning to tolerate uncertainty above).

13. Being able to assess one's own ability to achieve a desired outcome

An individual who is competent at assessing her own ability to achieve a desired outcome is able to realistically judge her own competence level and available resources (such as time, money and access to collaborators) in relation to a specific uncertain situation. This involves metacognition, which refers to the knowledge of one's own thought processes, as well as the "ability to adjust behavioural, environmental, and emotional functioning in response to changing … demands" (Mullen, 2011, p. 141).

14. Being able to engage a supportive network

An individual who is competent at engaging a supportive network is able to assess his own competences, admit when necessary that he may need support and has the ability to (actively) involve others in managing an uncertain situation. Networking involves more than simply knowing a lot of people, or even knowing the *right* people, it is also about getting them interested and committed to help (Tauritz, 2012a).

15. Being able to formulate a plan of action to deal with uncertainty

An individual who is competent at formulating a plan of action to manage an uncertain situation is able to identify what is needed to resolve the problem, is capable of dividing tasks and formulating a plan, as well as being practiced at adjusting the plan according to the chain of events. This competence is closely related to the competence of being able to prioritise amongst urgent problems. It additionally involves deciding how to resolve the prioritised issue. When people are faced with knowledge uncertainty associated with sustainability challenges, it may be necessary to develop action plans that take the *precautionary principle* (Petersen 2002; Van Asselt & Vos, 2006) into account. This principle states that when there is a significant possibility that particular activities could be harmful to humans or the environment, those activities should be discontinued.

16. Being able to work in, and contribute to teams with mixed skills and experience

An individual who is competent at working in teams with mixed knowledge, skills and experience is able, when faced with a complex and uncertain situation, to make a significant contribution to the team's achievements, and has strong social and communication skills. Such an individual also has a positive disposition towards solving complex challenges as a team, rather than as an individual. In addition, he can work effectively with collaborators with differing perspectives and contribute to the establishment of a team perspective and narrative.

17. Being able to use one's intuition as a source of information

An individual who is competent at employing intuition as a source of information is able to accept change, uncertainty and inconstancy by utilising the non-rational and intuitive side of thinking and decision-making. According to Merrian-Webster (n.d., para. 1), intuition can be defined as a "the power or faculty of attaining to direct knowledge or cognition without evident rational thought and inference". This competence is further derived from Gelatt's (1989) concept of *positive uncertainty*, which he developed in relation to counselling.

The next question concerns how these competences can best be taught. I postulate that teaching children how to manage uncertain knowledge through the development of uncertainty competences requires experiencing knowledge uncertainty in the learning environment. In other words, inviting uncertainty into the learning process provides the basic condition under which children can safely develop these competences (see Section 2.5.2 Characteristics of learning environments conducive to developing uncertainty competences). In the next section I will examine what has been said in the literature about the conditions required for such a learning process to take place.

2.4 Teaching uncertainty competences in an educational context

2.4.1 What have scholars written with respect to teaching about uncertainty?

There are a burgeoning number of scholars who describe the need for a teaching process that acknowledges uncertainty as a fundamental driving force in teaching. This creates space for perplexity and ambiguity where learners get to explore and discover new ways of thinking and doing things, with the aim of fostering citizens who can handle, perhaps even flourish, despite living in an uncertain world (Floden & Buchmann, 1993; Gordon, 2006; English, 2013). Dewey (1916, p. 148) refers to this *space* as the "twilight zone of inquiry", 100 years later English (2013, p. 55) speaks of the "in-between realm of experience and learning" and Buckingham (2014, p. 11) writes about the need for "an optimally productive measure of epistemological chaos". In an educational context characterised by epistemological chaos, knowing and not-knowing swirl around each other chaotically. According to Buckingham, teaching should not focus on eliminating this chaos, but should instead focus on teaching how to manage the chaos and uncertainty effectively.

Anderson and McCune (2013) advocate a "curriculum of dualities" (p. 166) in higher education which is characterised by "pairs of contrasting elements that are in creative tension" (p. 161), such as *support and challenge*, *local and international*, and *disciplined engagement and play*. They suggest that such a curriculum is necessary for students in higher education to, for example, cultivate dispositions of *resilience*, *courage*, *criticality* and *humility*. Fraser and Greenhalgh (2001) note, on the basis of their research regarding education for healthcare professionals, that building capabilities – "the extent to which individuals can adapt to change, generate new knowledge, and continue to improve performance" (p. 779) – requires the learner engaging actively and meaningfully with an uncertain and unfamiliar situation; transformation cannot be passively assimilated. They propose the need for non-linear, holistic, complex real-world learning experiences, and suggest that more research needs to be done regarding the use of storytelling in professional training. Several scholars use the metaphor of a *liminal space of learning* (Allen, 2014; Hall, 2010, 2014; Meyer & Land, 2005), which can be seen as a place where the learner feels stuck, disoriented and uncertain, when confronted with complex hard-to-understand knowledge. The individual passes through "a liminal cognitive space of unknowing in order to pass through the threshold of 'knowing'" (Allen, 2014, p. 33). It is also a space in which creativity and transformation occur and from which the learner emerges with new understanding of complex knowledge. While the above suggestions are not specifically directed at teaching children, they also seem relevant in terms of primary school education. What does not become clear from the above is how such constructs might be translated into practice. How is such a space for learning created? What do lessons look like that incorporate a liminal cognitive space or epistemological chaos?

Primary school teachers often start with deciding on the learning objectives or the topic for a new lesson. Topics explored in learning for sustainability (LfS) typically blur and cross the boundaries of environmental, political social and economic domains (see Section 1.2.1 and 4.4); they also involve multiple actors with differing goals, values and perspectives (Wals, 2003; Rebich & Gautier, 2005; Hall, 2010). Many researchers have discussed the confrontation with complexity, ambiguity and pluralism found in the context of LfS (Higgins, 2009; Sterling, 2010; Wals, 2010) and outdoor education (Beames, Higgins & Nicol, 2012; Beames & Brown, 2016) and highlighted that this confrontation can lead to the development of the capabilities needed to deal with such complex situations.

Mochizuki and Bryan (2015) wrote a conceptual paper discussing an elaborate list of capabilities learners need to develop in relation to climate change education (see Section 2.3.2); they also propose types of methods that would be useful for cultivating these capabilities. In particular, Mochizuki and Bryan (2015) suggest that methods suitable for the development of capabilities such as the ability to deal with one's emotions, the ability to adjust to novel situations and the ability to imagine alternate future events include: "participatory, experiential, critical and open-ended educational approaches that enable learners to engage critically and productively with the complexities of climate science…" (p. 18). Wals and colleagues (2007, 2009, 2016) consider facilitated social learning to be a very promising learning process in situations where a group of people needs to find solutions for complex and uncertain issues such as sustainability challenges. Wals further maintains that social learning involves individuals actively examining their assumptions and conflicting frames of reference, and through a process characterised by dissonance and transformative disruption, but also increasing trust and social cohesion, create new perspectives and take collective action.

It is more challenging to find scholars who have conducted rigorous empirical studies that aim to explicate how learning how to deal with knowledge uncertainty and developing specific uncertainty competences can be taught effectively in an educational context. Gardiner (2017) emphasises the need for teaching a *spirit of hope* and cautious optimism in order to empower students with regard to handling what he refers to as *future loss*. This term refers to acquisition of “information that is irreconcilable with one’s previously held ideas of the future, both personal and more abstract, and thus feeling loss or grief for those ideas” (p. 246). He designed the academic course (and action research project) *Sustainability and the future* with the aim of cultivating the students’ anticipatory competence. This competence entails the ability to engage with the future, handle uncertainty and understand that the future can be shaped. The course drew on the *despair and empowerment work* of Joanna Macy and employed a mixture of active hands-on methods, such as trend analysis, scenario modelling, back-casting exercises, outdoor meditation and journaling. The students were asked to create ‘speculative futures’ for the municipality Vechta and present these at the end of the course.

Hall (2006, 2010, 2014) explored the merits of climate change education in higher education by interviewing academic teachers about climate change, and employing Perkins’ (1999) theories of troublesome knowledge and Meyer and Land’s (2005) theory of threshold concepts. On the basis of this study, Hall (2011) proposes a pedagogy for teaching about climate change that explicitly revolves around the concept of uncertainty and employs student-centred, multi-disciplinary, creative and interactive approaches. Hall does not, however, specify in great detail what kind of competences the students should be developing and how these approaches could support their development (see Section 4.4 for more information on topic selection). Valley, Fu and Jovel (2017) describe a study that examined the experiences of 199 undergraduate students who took part in a mandatory, 3rd year, community-based, transdisciplinary food security project. The findings suggest that flexible learning strategies, as well as the time set aside to form connections with the other group members and their community partners, supported the students when they experienced uncertainty caused by the unpredictability of working with communities and multiple stakeholders.

Barnett, Jordan and Langer

In the next three sections I discuss the work of three scholars in more detail: Ronald Barnett, Michelle Jordan and Ellen Langer. These scholars have significantly influenced my thinking with regard to teaching children the competences needed to handle uncertainty. Barnett's (2007, 2011, 2012) work, although largely focused on higher education, stimulated me to consider if it is possible to teach competences for an unknown future, which uncertainty competences to include in my framework, and what kinds of curricula support the development of particular competences. Michelle Jordan's (2010, 2013, 2014a, 2014b, 2015) research about the strategies that primary school children employ in collaborative design projects to manage uncertainty was very important, especially as there is very little research that examines how primary children actually manage uncertainty. If we want to improve children's abilities to handle knowledge uncertainty we first need to know what they are already doing. The third scholar, Ellen Langer (Langer, 2014, 2016), proved crucial in developing my understanding of teaching strategies that primary school teachers can implement to help children develop the ability to handle uncertainty and ambiguity. Few scholars have focused on concrete teaching strategies that can support primary school children in their development of the competences needed to deal with complex and uncertain problems, where one cannot simply reduce uncertainty by gathering information. Langer's work is one of the exceptions and her ideas about the use of conditional language in the classroom proved to be crucial in the examination of my data. These three lines of research will be explored in some detail.

2.4.2 Barnett's framework for transformational education

Barnett (2011) argues that which competences individuals will need in the future is unknown and therefore suggests focussing on dispositions instead such as a will to learn, to encounter strangeness, to engage, to listen, and to live with ineradicable doubt. He also highlights important qualities that students (in higher education) should develop, such as courage, integrity, self-discipline and respect for others (Barnett, 2007). In his framework for transformational education (2012) he describes different curricular choices that teachers can make (see Figure 2.1 below). The horizontal axis characterises a curricular design that ranges from *no risk* (negligible amount of uncertainty) to *high risk* (ample amount of uncertainty). The vertical axis represents a curriculum that ranges from *educational development* to one that emphases *transformational education*.

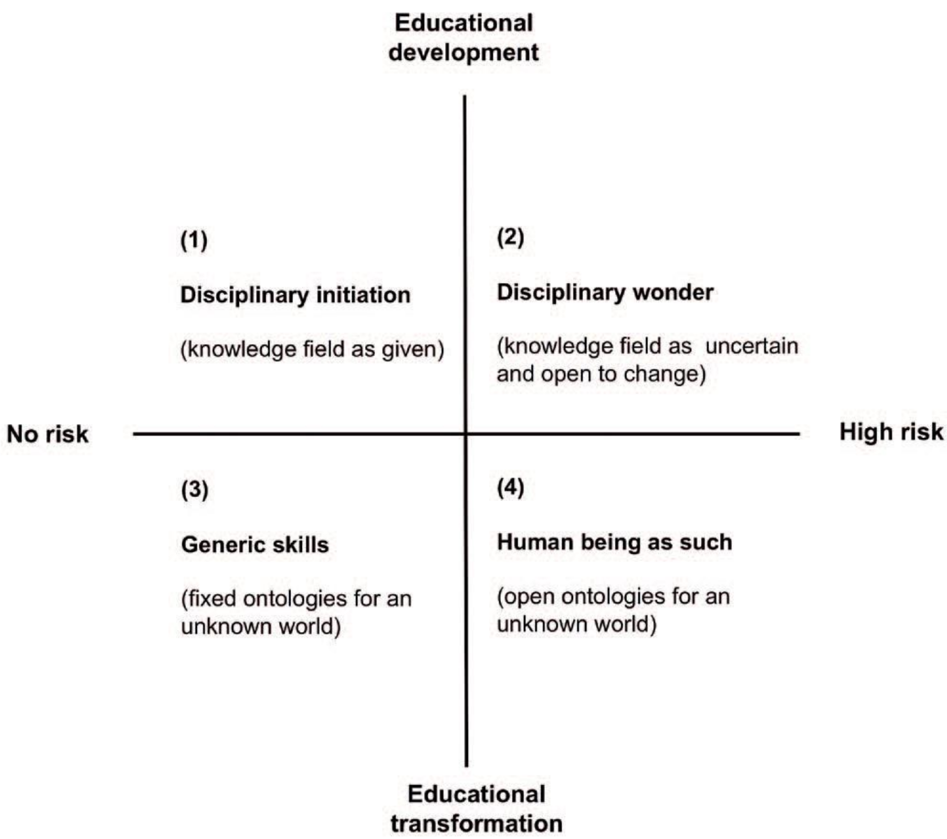

Figure 2.1: Barnett's framework for transformation education (2012)

The upper left quadrant is characterised by pre-determined aims and objectives. Uncertainties are minimised and students acquire specific knowledge and skills. The upper right quadrant features ample uncertainties and imaginative curricula constructed to prepare students for managing complex challenges. The third quadrant represents the development of specific skills and the transformation of students into individuals who are better prepared to deal with an uncertain world. However, these curricula are in themselves essentially risk-free, and therefore afford limited opportunities for students to learn how to manage risky and uncertain situations. Quadrant 4 demarcates a field that is both high-risk and transformational in character and is devised to prepare learners for an unknown future; Barnett (2012) refers to this as "transformation of human being" (p.74). This quadrant essentially reflects a supercomplex world in which individuals find themselves confronted with multiple descriptions of reality and encounters with previously unknown challenges and uncertainties. Current knowledge and skills are arguably not adequate for managing these situations, which necessitate humans who are, for example, able to and prepared to continuously learn, show empathy, and deal with and even celebrate uncertainty.

Barnett's framework is a helpful tool for considering curricula which could be employed for the development of the various uncertainty competences (See Table 2.2). For example, the ability to find, evaluate and utilise information and the ability to assess the credibility of knowledge sources fit into Quadrant 1. The ability to respond in accordance with the underlying probabilities fits into Quadrant 2. The ability to reason fits into Quadrant 3. Some of the uncertainty competences that are not typically taught but could be essential for managing knowledge uncertainty fit clearly into Barnett's Quadrant 4. These include the ability to accept not knowing what will happen or what the right answer/action is, the ability to use uncertainty as a catalyst for creative action and the ability to use one's intuition as a source of information. Barnett underscores the relevance of education appropriate to Quadrant 4, asserting that predetermined learning objectives as are central in narrowly defined competency-based education, do not suffice in learning how to deal with uncertainty. It seems, however, imprudent to dismiss the development of specific competences as being of lesser importance than cultivating the dispositions and qualities that Barnett refers to. I suggest that acknowledging this tension, and deliberately teaching the broad spectrum of uncertainty competences, which include both the former and the latter, is called for (see Section 2.3.3). Although Barnett provides some global ideas about the kind of learning environment that should be designed for teaching specific uncertainty competences, it is Jordan (2013, 2014a, 2014b, 2015) who actually observed how children managed knowledge uncertainty in a classroom setting.

2.4.3 Jordan's framework for children's strategies for managing uncertainty

Jordan and McDaniel (2014a) ask the questions: "what knowledge, skills, practices, and attitudes do people need to deal effectively with nonlinear interactions, dynamic unfolding, self-organisation, emergence, and co-evolution? What experiences do learners need to have; in what practices do they need to engage?" (p.256). The authors call for educators to help students navigate our complex and uncertain world by supporting students in feeling comfortable when confronted with uncertain situations. They further suggest that the students should increase the range of strategies they can employ to manage uncertainty and that they develop an understanding of system dynamics. Lastly, they propose that students learn how to adapt themselves in response to changes in the environment. I agree with Jordan and McDaniel (2014a) that it could well be beneficial for children to learn to consider unanticipated as well as anticipated outcomes (and to understand that living in an unfolding world precludes full prediction of the future). Some uncertainties can be reduced by finding required information, but other uncertainties may be irreducible. That educators can play an important role in teaching children uncertainty competences such as the ability to accept not knowing (what will happen or what the right answer/action is) is apparent from the findings of this study (see Chapters 4-8).

When Michelle Jordan set out to find answers to the question "What competences do children need to manage uncertainty?" she could not find studies that precisely conceptualised the forms and sources of uncertainty confronting children in the classroom. Nor did she find studies that described in much detail the range of strategies that students used to handle knowledge uncertainty during various academic tasks and how they did this in a collaborative setting. Jordan (2010) postulates that the combination of limited knowledge regarding new academic content, ambiguity inherent in creative tasks, as well as the social interactions fundamental to team work, require the ability to handle uncertainty. Jordan (2010, 2013, 2014a, 2014b, 2015) introduces collaborative robotics engineering projects as a form of academic task that affords students opportunities to learn how to manage uncertainty.

Strategies and tactics for managing uncertainty

A fifth-grade class studying robotics engineering was observed and interviewed over an entire school year. Jordan (2010) investigated how the children (10-11 years) communicated with each other while working in small groups and designing and building environmentally beneficial robots. In the first two of three subprojects the students followed well-structured instructions that introduced them to the materials and design practices of robotics engineering. In the third project the children were confronted with an *ill-structured task*; the learning goals were not pre-determined as the students were asked to make group decisions about what kind of robot to create, how to create it, actually construct it and finally assess if their robot met the goal of resolving their chosen sustainability challenge.

Four overarching strategies were identified as having been employed by the children to manage uncertainty: reduce, ignore, maintain, and increase, emerged from Jordan's (2013) data. These strategies are similar to the three categories of uncertainty competences developed by Tauritz (2016): learning to cherish uncertainty, learning to tolerate uncertainty and learning to reduce uncertainty (see Section 2.3.3). Jordan's (2010, 2015) findings also revealed that, within her four categories, the students employed a wide range of tactics to manage the uncertainty they encountered. These tactics are comparable to the uncertainty competences I introduced in Tauritz (2012a). The students in Jordan's study (2010) differed in the range and frequency of the tactics they employed, as well as in their willingness to acknowledge and entertain uncertainty. Examples of the tactics they used to reduce uncertainty are "analyse the issue", "trial and error experimentation" and "request information or explanation from [team] members" (p. 144). Examples of tactics used to ignore uncertainty include "avoid", "blame/justify uncertainty on an external source" and "persist" (p. 145). Examples of tactics employed to maintain uncertainty are "acknowledge", "share ideas to socially construct actions, decisions, or solutions (sense-making)" and "express doubt" (p. 146). An example of a tactic to increase uncertainty is "open the problem space" (p. 146). The students employed a wider range of these tactics while designing the environmentally beneficial robot for which they had been provided with less structured instructions than they had been given for the previous two tasks. Interaction with their peers proved important as most of the tactics for handling uncertainty that they used relied on social support.

Peer support and managing uncertainty

Jordan (2014b) argues that, even though managing uncertainty is often viewed as an individual pursuit (Sorrentino & Roney, 2000), it can also be regarded as a social endeavour. The students in Jordan's (2014b) study responded in a socially supportive manner when uncertainty was shared by the group, and when other group members believed that uncertainty was warranted. The response also depended on the degree to which the group members were experiencing uncertainty about other topics, their previous experience with the particular group member expressing the uncertainty, and finally the relative social position of that member. When the students did not get this support, they found that their options for dealing with uncertainty were greatly reduced. According to Jordan (2014a), relationships are students' primary resources in responding creatively to our changing world. The uncertainty competence being able to work in teams with mixed knowledge, skills and experience discussed by Tauritz (2016) is closely related. Both recognize a potential benefit in students learning how to understand people with diverse perspectives and provide support to group members when uncertainty arises; classroom discussions and reflective exercises might be of use to develop these abilities. Jordan (2013) proposes that assisting students with the development of their communication skills and their ability to build relationships may be among the most important goals in preparing students for an uncertain world. See Section 6.2.2 regarding the emergence of two new uncertainty competences focused on communication about uncertainty.

Creative thinking and uncertainty

The collaborative design projects presented the children with several communication challenges. The skills needed to deal with these challenges are key to effective collaborative problem-solving. Jordan writes about the importance of interpreting group member's utterances and actions and assessing how certain one feels about the accuracy of that interpretation (probabilistic orientation). Creative thinking requires the individual or group to suspend their judgement providing space for creativity to flow with minimal impedance. Jordan (2013) asserts that allowing uncertainty to be present for a while can be more useful than trying to reduce it as quickly as possible. She suggests that finding creative solutions may require the deliberate generation of uncertainty in order to stimulate the search for innovative ideas (2014a,). This raises the challenge of resisting a common desire to reduce uncertainty by seeking agreement. Jordan's (2013) findings show that it could be important for teachers to actively prepare students for brainstorming (and suspending judgement) through direct instruction about people's susceptibility to premature consensus, its price and the value of maintaining, at least temporarily, uncertainty. Additionally, Jordan suggests that teachers should explicitly discuss the knowledge uncertainty the students can expect to encounter during the project.

There are clear parallels between the overarching strategies (reduce, ignore, maintain and increase) which Jordan (2014b) mentions and the categories of uncertainty competences I distinguish, learning to reduce uncertainty, learning to tolerate uncertainty, and learning to cherish uncertainty (Tauritz, 2016). An interesting difference is the strategy to ignore uncertainty by first *dismissing or failing to consider uncertainty expressed by others*, second *blaming uncertainty on an external source* or three *keep going, persisting* that Jordan observed in her study. Ignoring uncertainty and persisting with one's task might well be an effective interim strategy for dealing with uncertainty.

Although Jordan makes some tentative suggestions regarding the possible teaching strategies the teacher can employ, she acknowledges that this was not the focus of her research. The way Jordan employs the word tactic can be described in terms of a specific method or action employed to manage uncertainty. Although the competences and the tactics are similar, Jordan focused on what the children were doing, whereas my interest was in what the children were learning. An uncertainty competence can be described in terms of an ability a child could develop to manage uncertainty. Hence the uncertainty competences were formulated as learning objectives. As my search for specific educational approaches for teaching children uncertainty competences continued, I came across the work being done by Ellen Langer and her colleagues. They delve into educational approaches that can be employed to encourage an open and creative attitude towards uncertainty.

2.4.4 Langerian mindfulness and conditional language in the classroom

In the 1970s the terms *mindlessness* and *mindfulness* were introduced to the field of social psychology by Ellen Langer (2014), a Harvard University professor who specialised in the psychology of learning. Ellen Langer's ideas have attracted broad attention over the years, resulting in 2014 in a 25th Anniversary edition of her book *Mindfulness*, originally published in 1989. Numerous interpretations of mindfulness exist. Mindfulness is, for example, well-known for being at the heart of Buddhist teachings, although it can, according to Kabat-Zinn (2003), in fact be viewed as universal. Kabat-Zinn (2003) describes mindfulness as "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment" (p. 145). He views mindfulness as a human capacity, which can be cultivated and refined through, for example, meditation practice. Wallace & Shapiro (2006) also describe mindfulness as *sustained non-distraction*. Other scholars, such as Bishop et al. (2004), propose a "two-component model of mindfulness" (p. 232) which includes "self-regulation of attention" as well as an open, curious and accepting disposition towards one's experiences in the present moment.

The term mindfulness as Langer uses it refers to "a flexible state of mind in which we are actively engaged in the present, noticing new things and sensitive to context" (Langer, 2000; p. 220). Moafian, Pagnini and Khoshsima (2017) argue on the basis of their Persian evidence-based study that mindful people are more sensitive to the novel and unexpected; they are both novelty seeking and novelty producing. An individual with a propensity toward novelty producing readily examines previously constructed categories from multiple perspectives. This leads, according to Ritchart and Perkins (2000), to a flexible use of information and deep understanding. The latter depends on the learner exploring and testing ideas viewed from differing perspectives. Mindful learners are therefore better at creatively responding to uncertainty. In contrast, when people act mindlessly their thoughts, emotions, and behaviours are determined by previously *programmed routines* (Haigh, Moore, Kashdan & Fresco, 2011) and they risk remaining "stuck in a single, rigid perspective … oblivious to alternative ways of knowing" (Langer, 2000, p. 220).

Chanowitz and Langer (1981) introduced the concept of *premature cognitive commitment*, which refers to an (over-)reliance on previously acquired knowledge that has been accepted as factual and is not questioned in novel situations. This can be a result of continued exposure to a particular situation, or as Langer and Piper (1987) assert, it can also happen when learners on initial exposure aren't encouraged to question and consider the information presented. Of course, it is not always possible (or desirable) to pay attention to every detail in a situation or question every piece of information. Langer and Piper (1987) therefore set out to answer the question if "there was a way to prevent premature cognitive commitments without mindfully attending to everything ..." (p. 281).

According to Langer (2000), mindlessness is a consequence of how we learn and are exposed to information. The most familiar way is through repeating some behaviour so often that it becomes a routine that requires very little thought. The second way is related to the form in which information is communicated and the way this information is processed. More precisely, when learners are exposed to unconditional or absolute language they, according to Langer (2014), are less likely to question that information and to look at it from new perspectives. Unconditional language refers to communicating as if something is true and factual. Conditional or probabilistic language "represents a probability statement rather than an absolute truth" (Langer et al., 1989; p. 141). In other words, the statement could be true, but is not necessarily true. A consequence of unconditional instruction is that information is regarded as having one single meaning (Langer & Piper, 1987). As a result, the information may not be reconsidered even in situations where it would be beneficial to do so. This could leave learners inadequately prepared for changing circumstances in an uncertain and complex world. According to Ritchart and Perkins (2000), ambiguous situations, such as those created by introducing conditional language in the classroom, make learners more mindful as they are stimulated to actively process the information. The learner engages not in the act of merely memorising the information provided, but in deliberately making sense of the ambiguous situation. Studies by Langer (2014) have shown that when students are taught in a conditional manner, which allows uncertainty regarding the presented information into the classroom, they have a less rigid perspective (Langer & Piper, 1987), are more mindful and sensitive to context (Langer, 2000), are able to question that information and to employ it more creatively (Langer et al., 1989). The creation of new categories involves re-examining ideas (Davenport & Pagnini, 2016) and potentially letting go of beliefs about the (un)certainty of information. I propose that it also involves lateral thinking, leaving behind preconceptions and encouraging new approaches to problem-solving. Uncertainty can thus become an invitation to let go of the obvious and create new understandings (Fatemi, 2016). A major premise of my thesis is that the unknown need not be perceived as something to fear as long as tools to deal with it are available. In that case, knowledge uncertainty can be a catalyst for creative action. The uncertainty competences discussed in Section 2.3 are designed with this in mind. Additionally, Langer's focus on conditional language suggested the importance of exploring how the use of conditional language related to both dealing with and communicating about degrees of (un)certainty.

2.4.5 Unanswered questions about teaching uncertainty competences

Although scholars increasingly emphasise the need for educational strategies incorporating uncertainty in the learning process (Barnett, 2012; English, 2013; Floden & Buchmann, 1993; Forrest et al., 2012; Fraser & Greenhalgh, 2001; Gabella, 1995; Gordon, 2006; Jordan, 2015; Langer 2014; Morrison, 2008; Tauritz, 2012a, 2016), there is a clear lack of empirical data demonstrating how theoretical models can inform the practice of education regarding teaching uncertainty competences. Barnett's framework for transformation education (2012) provides some clues about the dispositions learners should be developing in preparation for an uncertain future; it also suggests some general educational approaches that could contribute to developing these dispositions. However, Barnett (2012) is not very specific about the steps teachers should take to create effective learning environments. Jordan's (2010, 2014b, 2015) work centres around one educational format, collaborative robot engineering projects and focused within this context on the children's strategies for managing uncertainty. She did not investigate how these strategies might be improved or if these or other strategies might be effectively taught. Langer and her colleagues (1987, 1989, 2014) offer some more concrete teaching techniques that teachers can apply in their lessons by taking the use of conditional language into consideration in their interactions with the children. However, as this review of the literature indicates, little is known about concrete learning environments that are conducive to developing uncertainty competences. In the next section I examine the concept of a learning environment and discuss what is known from the literature about characteristics that make a learning environment potentially suitable for developing uncertainty competences.

2.5 Learning environments conducive to developing uncertainty competences

2.5.1 Learning environments

With this study, I set out to understand what makes a learning environment in the context of primary school education conducive to the development of uncertainty competences. I define a learning environment in terms of the *physical (or virtual) setting*, in which a *learner* finds him- or herself trying to make sense out of the learning experience, working together with, and affected by co-learners (*group*), as well as under the active guidance of a *teacher*. The *teaching strategy*, *cultural institutions* and *classroom procedures* guide the children and the teacher in their pursuit of individual or group learning objectives (adapted from Tauritz, 2012b). See Figure 2.2 for an overview of the key elements of a learning environment.

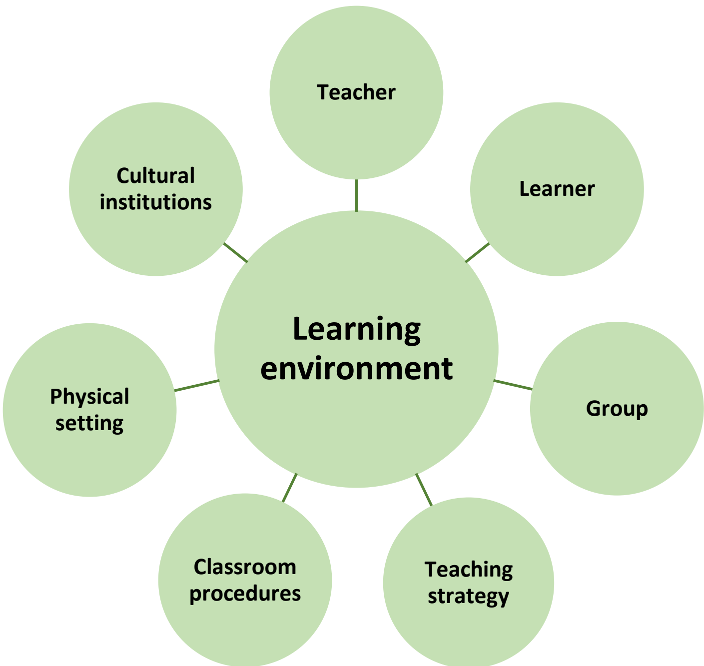

Figure 2.2: Key elements of a learning environment (adapted from Tauritz, 2012b)

When considering the design of learning environments conducive to developing uncertainty competences and specualting about which ingredients are required, it is useful to briefly examine the tenets of *affordance theory*. Perceptual psychologist James J. Gibson (1979) coined the concept of *affordances*, and referred to the properties of the environment that provide an animal “either for good or ill” (p. 127). In the words of Kirschner (2002), affordances refer to “the relationship between an object’s physical properties (artifacts) and the characteristics of an agent (user) that enables particular interactions between agent and object” (p. 12). Researchers have long been debating whether affordances are properties of environmental features that provide possibilities and opportunities for particular behaviour and which exist independent of being perceived by animals and humans (Heft, 1988; Gibson, 1979), or are instead, as environmental psychologist Chemero (2003) asserts, vested in the relationship between the individual and perceived environmental features. In other words, Chemero suggests that affordances depend on an individual’s perspective regarding the characteristics of a particular enivornment. It is Chemero’s analysis that I find most useful for the exploration of learning environments.

Translating Chemero’s interpretation to the complex and inherently uncertain dynamics of the classroom, affordances reflect the possible relationships among the children, teacher and the other elements of the learning environment. A particular topic, for example climate change, will not afford the same learning possibilities for each child, or even to the same child at different moments in time. Some relationships are obvious, such as a teacher influencing a child’s learning process, others such as to the children’s previous experience, cultural background and prior knowledge of the topic can be less apparent. Disagreements that might arise in the classroom following a controversial video about climate change inroduced by the teacher could result in interesting discussions. The teacher might respond to the children’s engagement by always including that video in her lessons on climate change. However, inviting uncertainty into the learning environment and nurturing the development of uncertainty competences requires the teacher to be mindful, and pay attention to variability and continuous reshaping of the learning environment (Langer, 2016).

In Chapter 4 I discuss in more detail one of the key elements of the learning enivronment, namely the teaching strategy and its principle components, which include learning objectives, learning activities, teaching resources, and language and classroom questioning and how they relate to the development of uncertainty competences. First, however, it is useful to examine the characteristics of a learning environment in which children can develop their uncertainty competences.

2.5.2 Characteristics conducive to uncertainty competence development

When certain characteristics of a learning environment are present, they support the incorporation of uncertainty in the children's learning experiences. Awareness of these characteristics can provide guidance for shaping the learning environment in such a way that it enhances the development of uncertainty competences. The characteristics discussed in this section are largely theory-driven, although some emerged during the data analysis of the present study. The characteristics can be divided into three main categories:

1. Prerequisites for fostering uncertainty in the learning process
2. Introducing uncertainty into the learning process
3. Making uncertainty negotiable in the learning process

1. Prerequisites for fostering uncertainty in the learning process

The first category focusses on uncertainty in the learning process. Teachers are confronted with a conundrum: the seemingly unsolvable antithesis of a safe learning environment versus an uncertain learning environment. Defining a safe learning environment as one in which the individual learners feel they can take risks and display vulnerability as they explore their existing frames of reference as well as novel perspectives overcomes this dilemma. In such an environment learners can discuss their personal and their peer's views and opinions and enter into conflicts, whilst both teachers and students suspend their judgement regarding potentially conflicting perspectives (Clapper, 2010; Forrest et al., 2012). Students can in this way experience both uncertainty as well as a sufficient degree of safety to permit the development of uncertainty competences. The teacher's encouraging presence, positive guidance and reflection on the children's learning process are critical, not only because of the present learning experience, but also because of its potential effect on future learning (Clapper, 2010). Dweck (2007) emphasises how teaching based on a growth-mindset influences the risks children are willing to take in the classroom. According to Dweck, children with a fixed-mind-set believe that intelligence is a fixed ability one either possesses or does not; these children tend to avoid situations where they can make mistakes revealing their potential deficiencies. Children with a growth-mindset on the other hand, have learned that intelligence can be cultivated by dedicated and persistent learning effort (Dweck, 2012). With regard to the sustainability challenges we are facing, it seems extremely important for an individual to understand that resolving these complex problems will require perseverance and continuous effort. Teaching based on a growth-mindset therefore accomplishes two important objectives: it creates a safe learning environment in which children can explore and learn, and it cultivates skills and dispositions (among them the ability to deal with uncertainty) that potentially make children more able to respond to sustainability challenges.

There is another prerequisite for developing uncertainty competences and that is the willingness of teachers and children to overtly accept the concept of uncertainty (Hall, 2014). Doyle and Carter (1984) and Jordan (2010) describe how children often resist uncertainty and ambiguity in the classroom by asking for clear, specific guidelines and objectives in order to reduce the need for taking risks and minimise the possibility of failing assignments. Jordan (2014a) stresses that teachers should help children understand that the world is continuously changing and that it is therefore impossible to know for sure what the future will bring, especially with respect to complex systems. Some uncertainties can be reduced, while others are irreducible. In both cases, knowledge uncertainty needs to be accepted as an inherent part of life.

2. Introducing uncertainty into the learning process

The second category of the characteristics introduces uncertainty in the learning process. Stenhouse (1975) cautions that a focus on predetermined learning outcomes can limit the children’s genuine inquiry. In addition, Bolhuis (2003) suggests that a teaching approach that does not focus primarily on narrowly defined learning outcomes, but instead emphasises the learning process, will create space in the learning environment for uncertainty and ambiguity. Raab (2004) explains the importance and virtue of teachers resisting providing all the answers and instead becoming "experts in not knowing" (p.255), or what I prefer to call *teachers as expert explorers*, rather than *teachers as expert knowledge sources*. This shift requires the teacher to trust that this approach will lead to a better understanding of the learning content. Teachers will often have to deal with their personal feelings of uncertainty about the open-endedness of the lessons and the pressures of curriculum demands. A dynamic and emergent curriculum is one in which learning activities and learning are negotiated between the children and the teacher (Jones, 2012; Kinos, Robertson, Barbour & Pukk, 2016) and teachers respond to input from the children as it emerges during an evolving teaching process (Morrison, 2008). When teachers and children alternate roles, the responsibility children take for their own learning process increases. Of course, teachers remain responsible for facilitating the children's learning process (Raab, 2004; Shulman, 2005). The strategies for introducing uncertainty into the learning process create learning opportunities for uncertainty competence development and in doing so address the criticism regarding narrowly defined competency-based education.

3. Making uncertainty negotiable in the learning process

The characteristics in the third category make uncertainty negotiable in the learning process. According to Hall (2010, 2014) teachers do not generally teach explicitly about the concept of uncertainty in relation to complex, multi-disciplinary topics such as global warming. Hall explains that this is either the result of uncertainty being conceptually difficult to teach, so that teachers prefer to avoid it, or simply because teachers consider uncertainty intrinsic to multidisciplinary topics and don't see the need to talk explicitly about it. However, as scholars (Forrest et al., 2012; Hall, 2010) indicate, for children to develop a sound understanding of knowledge uncertainty, it is important to make it visible in the learning environment and discuss what it means regarding, for example, our knowledge about sustainability challenges. Hall (2010) emphasises how important it is for students to reflect on their own understanding of knowledge uncertainty by encouraging them to examine their own ideas and to discuss this explicitly with their peers. Other scholars (Shulman, 2005; Gordon, 2006) have also emphasised that children should be encouraged to clarify, question, assess, extrapolate, justify and re-examine their beliefs. Nel et al. (2008) argue that teachers can facilitate the learning process such that the children come to realise that by holding on to their previously formed ideas and theories, they are avoiding uncertainty and change. They further explicate that if children and teachers are to become comfortable with the concept of uncertainty it is logical for the teacher to revisit the concept frequently and with regard to different topics.

When teachers present information and instruction in conditional language (see Sections 2.4 and 10.4.2) children are encouraged to remain open to alternative interpretations. When encountering, at some later date, a different situation they will be more capable of re-examining that information and applying it mindfully and innovatively (Langer & Piper, 1987; Langer et al., 1989). Langer and her colleagues (1989) argue that children can become insecure when confronted with an unpredictable and uncertain world that does not adhere to strict rules. On the other hand, they point out, it could also be argued that children who are accustomed to conditional language in the learning environment will feel more secure as they are better prepared for a world filled with uncertainty and ambiguity. Claxton (2001) writes that learners are able to handle uncertainty if a confident teacher employs conditional language in a manner that suggests that uncertainty is an attribute of the information and not of the educator. In such a situation the teacher conveys the message to the children that people can remain confident in the face of uncertainty.

2.6 Conceptual Framework

As was discussed in Chapter 1, the aim of this study is the development of our understanding regarding the way in which we can teach children, in an educational setting, the competences necessary for dealing with knowledge uncertainty (see Section 1.4.2). In Chapter 2 I set out to develop a conceptual framework uniting my construct of uncertainty competences with the construct of suitable learning environments for developing uncertainty competences to support and organise my research. I explained in this chapter why the concept of uncertainty in education needs to be rethought if we want to prepare our children for an uncertain and rapidly changing future. I examined the literature pertaining to some well-known uncertainty concepts: uncertainty and ambiguity, (super)complexity and (super) wicked challenges, cognitive dissonance and cognitive disequilibrium, intolerance of uncertainty and intolerance of ambiguity, and uncertainty orientation. I argued that their negative connotations render them of limited value for use in lessons focused on developing uncertainty competences as they are relevant only to situations in which the focus is on reducing uncertainty. As important as this can be, the implicit belief that it is always both possible and desirable to reduce uncertainty is no longer viewed as incontestable.

I found the theoretical literature regarding teaching children in primary education how to manage complex and uncertain information, as well as the limited attention to potentially effective learning environments, insufficient for guiding my data collection and analysis. Although the literature does provide clues, there is very little in the form of empirical research that specifically examines teaching many of the competences needed to deal with uncertainty. In addition, the literature does not provide any information about the educational approaches Scottish teachers currently might take to teach about complex and uncertain topics. I have therefore further developed two of my own literature-based concepts.

In Sections 2.3 and 2.5 respectively, I define *uncertainty competences* and *learning environments conducive to the development of uncertainty competences*. These two key concepts form the core of my conceptual framework. The concept of uncertainty competences is based on earlier published work (Tauritz, 2012a) but has been extended and further refined during the literature review phase of this study (Tauritz, 2016). One of the key elements of the learning environment is the teaching strategy (see Section 2.5.1). Up and until the data collection phase I had used the terms process design and teaching strategy interchangeably, but in my interactions with the teachers it became evident that discussing teaching strategies resulted in clearer communication. My working definition for the teaching strategy was as follows: the educational approach taken by the teacher to achieve particular learning objectives through careful selection of learning activities, topics and questions. The concept of a teaching strategy as employed in this study evolved during the research process, especially during the data analysis phase and will be further discussed in Chapter 4. This conceptual framework guided my data collection and supported the subsequent analysis and discussion of my findings. In consideration of the preceding analysis of the literature and the dearth of empirical studies about teaching uncertainty competences in general, and in particular in primary schools (in Scotland), my study was guided by the following two working research questions:

1. Which teaching strategies do Scottish primary teachers employ to teach about complex and uncertain sustainability challenges?
2. Which uncertainty competences are being taught in Scottish primary education?

I adopted an interpretive multiple case study approach to address these questions. In Chapter 3 I will discuss in-depth the methodology that I employed in my study.

2.7 Summary

In Chapters 1 and 2 I made a case for the need to rethink our approach to education if we want to better prepare our children for an uncertain and rapidly changing future. I examined the literature in search of uncertainty concepts that could inform such educational reform. In Chapter 2, I described some well-known uncertainty concepts and argued that negative connotations often limit their value for use in the classroom. I also discussed suggestions made by many scholars that teachers should encourage children to develop abilities and dispositions that reach beyond teaching content-knowledge. My focus is on a specific set of abilities, which I call u*ncertainty competences*. I define these as: the knowledge, cognitive, practical, social, and communication skills, strategies, dispositions, motivation, and values, as well as the ability to mobilise these attributes in the right place and at the right time in order to make effective decisions and, if necessary, take action when faced with knowledge uncertainty.

I next explored what scholars have written about teaching strategies and creating learning experiences that could support the development of uncertainty competences. Though the literature is limited in what is known about teaching primary school children uncertainty competences in an educational setting, it is possible on the basis of research often directed at students to generate ideas by extension. Three scholars in particular have influenced my thinking. Ronald Barnett’s framework for transformational education encouraged me to think carefully about whether it is or is not possible to teach uncertainty competences for an unknown future. I argue that this is possible, although it will be necessary to develop skills and dispositions that would support life-long learning. Michelle Jordan's important research focuses on the tactics that children employ to manage uncertainty and, although she examined these strategies in the context of collaborative engineering projects, I propose that they can be applied in other contexts as well. As Jordan points out, if we want to enhance children's abilities at managing uncertainty, we first need to know what children are already doing when confronted with uncertainty in a variety of (educational) contexts. Lastly, Ellen Langer provided concrete suggestions regarding the use of conditional language in the classroom and its potential effect on the children's classroom behaviour. Throughout Chapter 2, I have described how criticism made regarding competency-based education has been addressed in this study by including a broad range of specific uncertainty competences including competences that are acknowledged to be more difficult to measure. Further, characteristics of the learning environment necessary to the development of the entire range of competences is discussed.

This review of the literature left me with many questions regarding effective learning environments and teaching strategies. Two key concepts, uncertainty competences and a learning environment conducive to developing uncertainty competences, form the core of the conceptual framework that guided the data collection and supported the data analysis. I have written theoretical discussions regarding the development of uncertainty competences in the past. Conducting the current study afforded me with the opportunity to take an empirical approach and go into classrooms to talk to and observe primary teachers teaching about sustainability challenges characterised by complexity, uncertainty and ambiguity. In Chapter 3, I will discuss the methodology that I employed to answer the research questions.

Chapter 3 Methodology

> Qualitative inquiry demands meticulous attention to language and images, and deep reflection on the emergent patterns and meanings of human experience.
>
> (Saldaña, 2016, p.11)

3.1 Introduction

This chapter describes the choices and the support for these choices with regard to the employed research methodology in pursuit of answering the research questions (see Section 2.6). In writing this chapter I have referred to a research guide that I had developed before starting the data collection. It described in detail the process of selecting schools, discussing the observations with the teachers, obtaining consent, planning, organising the recording equipment, organising the classroom and collecting the observation data, labelling and storage of the data, the use of the data to inform the other stages of the data collection, and the initial questionnaires for the focus group and teacher interviews. This guide helped clarify the steps to be taken, especially of the data collection and management of the data, before heading out into the field. At a later stage it also proved helpful in chronicling the methodology employed in this study.

In Section 3.2 the interpretive research paradigm underlying my research is established and the ontological and epistemological assumptions which form the foundation of this research are discussed. Section 3.3 outlines the multiple case study research design that I have employed. The study population and sampling are outlined in Section 3.4 and are followed by a discussion of the ethical considerations and data management decisions regarding the current study in Section 3.5. Subsequently, in Section 3.6, I describe the six data collection methods used for gathering the data. Section 3.7 focuses on the selected interpretive content analysis approach and, lastly, Section 3.8 deals with the procedures employed to verify the data collection methods.

3.2 Research paradigm: interpretive

I have chosen to employ an interpretive approach in my research because it affords a research perspective well suited to studying the intricate question of how to teach children how to manage complex and contradictory information in a primary school setting. Accordingly, I examine in a holistic manner the way in which the teacher and children interacted during the observed lesson, and listened thereafter to the children and then to the teacher talk about the lesson's multifaceted sustainability topic. In this way I was able to capture the individual teaching strategies employed as well as the differences between those strategies.

3.2.1 Ontology and epistemology

My study is therefore underpinned by an interpretivist paradigm. According to O'Donoghue (2007) a research paradigm is based on a set of assumptions about reality—what we know and understand to be true (*ontology*)—as well as beliefs concerning the manner in which knowledge is generated and accepted as valid (*epistemology*). Bracken (2010) argues that together they form the philosophical premises on which the arguments that justify the research process and findings are based. As Cohen, Manion and Morrison (2007) state, positivist research designs are based on the premise that social realities exist independently of the researcher and are objectively knowable. Interpretive researchers, in contrast, acknowledge that all participants in a particular situation understand, describe, and explain that situation from their own personal perspective. The presupposition is then that there is no single external reality and that, in fact, all individuals socially construct reality. Taken literally this means that there are as many socially constructed realities as individuals. This ontological view-point to which I subscribe logically suggests the employment of an interpretivist epistemology.

Schwartz-Shea and Yanow (2012) explain that researchers cannot access these different realities directly; their role therefore lies in the interpretation of the meaning constructed by the different actors in particular contexts. Understanding our world in general, and the phenomenon under investigation in particular, involves listening to and observing these multiple perspectives. It is as a result, not possible to understand the teaching process by focusing solely on the teacher or solely on the child. It is in the interaction between the two that 'the magic' does or does not occur. At the same time, it cannot be forgotten that the interpretive researcher is not distinct from the phenomenon being explored. Researchers in their turn observe, listen, and filter data through their own belief system, prior knowledge and experience. In addition, as Van Bommel (2008) rightfully states, the role of the interpretive researcher is not merely to construct narratives describing a situation, but also to actively come to “a conceptual understanding of that situation that is interpretive but also theoretical in character” (p. 48). The aim of this study is not to formulate generalised rules of the kind that are often products of positivist research, but rather to search for and identify context-specific meanings (Schwartz-Shea & Yanow, 2012).

3.2.2 Hermeneutics

In this research project I draw on hermeneutic methods which argue that humans project meaning onto “the physical, linguistic, and enacted artefacts they create” (Schwartz-Shea & Yanow, 2012; p.41) such as buildings, art, drama, texts, photographs, etc. (Van Bommel, 2008). According to Schwartz-Shea and Yanow (2012), hermeneutic researchers initially focused on meaning embedded in such artefacts; this was, however, later extended to the analysis of meaning embedded in spoken language. To enhance our understanding of teaching uncertainty competences I focused on uncovering the meaning teacher and children embedded in their spoken and written language with regard to managing uncertainty. The data sources central in my study are the transcripts from the classroom observations, focus group interviews and teacher interviews, as well as the teaching resources (e.g. PowerPoint presentations or information sheets) and the children’s assignments (e.g. posters and PowerPoint presentations). I expressly examined how unconditional and conditional language and questions were used by the participants in those specific instances in which they communicated about complexity and uncertainty, as well as in relation to teaching the competences needed to handle knowledge uncertainty. For analysis of many examples of such instances see Chapters 4-8. In accordance with Stake (1995), I focused on particular instances carefully disassembling them, examining and interpreting them, and then synthesising the instances in a more holistically meaningful manner.

This need to understand the whole is central in interpretive research and is often referred to as the hermeneutic circle or spiral. Schwandt (2000) describes the hermeneutic circle as a method based on the fundamental idea that “in order to understand the part (the specific sentence, utterance, or act), the inquirer must grasp the whole (the complex of intentions, beliefs, and desires or the text, institutional context, practice, form of life, language game, and so on), and vice versa" (p. 193). Another characteristic of the hermeneutic circle is the notion that there is no fixed starting point for a research study. According to Schwartz-Shea and Yanow, (2012) "the process of sense-making begins wherever the individual 'is' in her understanding at that moment, with whatever grasp of things she has at that time" (p. 30-31). It also implies that there is no real conclusion or ending to the process of sense-making, but rather that it is an ongoing process with temporary pauses before continuing on the interpretive path.

3.2.3 Abductive inquiry process

I had already taken my first steps along the research path investigating teaching children how to manage knowledge uncertainty many years before the commencement of my PhD programme. I had first become interested in what I later went on to describe as *teaching uncertainty competences* while working as an environmental education developer. The question I wanted to answer then and still wish to answer is: How can we teach children in an educational setting how to manage the knowledge uncertainty and complexity (see Table 2.1) omnipresent in today's world? As elaborately detailed in Chapter 2, I discovered that the literature did not provide a conclusive theoretical lens to assist me in answering this question. Therefore, drawing on the prior knowledge I had acquired as a developer of environmental education, as well as my theoretical pre-knowledge as a social researcher focused on environmental education and communication, I began to formulate my own theories in search of answers. This resulted in the construction of several models (Tauritz, 2012a; Tauritz, 2016). These models provided a basis for the questions I wanted to answer with my PhD research and at the same time suggested a tentative search direction. Such a research approach, beginning with a researcher's interest in a phenomenon for which theoretical explanations are lacking, is called an abductive research approach (Charmaz, 2016; Friedrichs & Kratochwil, 2009; Reichertz, 2007). The more commonly known reasoning approaches are the *deductive inquiry process* and the *inductive inquiry process*. The *deductive process* is, according to Schwartz-Shea and Yanow (2012), typically associated with quantitative research and begins with existing research theories that in turn lead to hypotheses and testable concepts, which are then tested in a specific context. Data is collected until the theory can either be confirmed or rejected. In a deductive reasoning problem there is only one logically valid answer (Goswami, 2004). An *inductive approach,* in contrast, begins by conducting observations in a specific context, noticing patterns, formulating a tentative hypothesis, and subsequently exploring this hypothesis from which general theoretical rules could potentially be developed.

Abductive reasoning in social scientific inquiry provides another approach to knowing. This approach, first described in US pragmatism by Peirce (1931-1958), challenges the dichotomy between the well-known inductive and deductive reasoning approaches. Peirce (1931 – 1958 (CP) 5: 171; emphasis in original) argued that "Deduction proves that something *must* be; Induction shows that something *actually* is operative; Abduction merely suggests that something *may be.*" In contrast to induction or deduction, abduction embraces a continuous going back and forth between what is puzzling and possible explanations. Although researchers engaging an abductive inquiry approach often say that it is their case that is puzzling, according to Schwartz-Shea and Yanow (2012) it would be more correct to say that the puzzle stems from the tension between the researcher's expectations (based on the knowledge that they bring with them into the field) and the actual situation that the researcher encounters. Schwartz-Shea and Yanow (2012) explain "the effort to resolve the puzzle and make the theory-event or event-event contrast less anomalous is what "abducts" the researcher's reasoning, capturing her thinking and leading or directing her explanatory efforts to a new bit of theorizing (often revising or extending an existing theory in some fashion)" (p. 29).

This is in fact what happened to me: in my preface I referred to having come to this research in some ways as an outsider, open to the power of surprise. I was interested in the phenomenon of teaching primary school children uncertainty competences through teaching about complex and inherently uncertain sustainability topics. My theoretical presuppositions led me to expect to encounter teachers purposefully selecting a teaching strategy and working out a clear lesson plan to teach about the chosen complex topic; I was surprised by the situation I actually encountered in the field. Only two of the five teachers in my study provided me with detailed lesson plans. It seemed that the teachers were often employing a teaching strategy that was only in part purposefully selected. Additionally, and importantly, as I set out to learn more about teaching uncertainty competences, I realised that I had not taken into account the fundamental importance of being able to communicate about the certainty of knowledge in learning how to manage complex and uncertain sustainability challenges.

Blaikie (2004) describes abduction as "the logic used to construct descriptions and explanations that are grounded in the everyday activities of, as well as in the language and meanings used by, social actors" (p. 1). By observing teachers teaching a lesson about a complex sustainability topic that they had designed themselves, conducting a focus group with a group of children who took part in the lesson, and finally talking to the teacher in an in-depth interview, I set out to discover what the teachers' motives were in employing particular teaching strategies and what largely tacit knowledge was fuelling those decisions (Blaikie, 2004). I began developing new theory, drawing on my prior theoretical knowledge and previous experience in developing educational projects and other educational research projects, in such a way as to make the situation that I encountered in the field understandable and explainable. What ensued was a dynamic and iterative process of immersion in the field, encountering puzzles, trying to explain them, revisiting my models and the literature, all the while gathering empirical evidence to support, refine or refute my theories (Schwartz-Shea & Yanow, 2012). It is this process of repeatedly moving back and forth between collecting new data and refining theories until the most plausible explanation has been found that, according to Charmaz (2006; 2011; 2016), characterises abduction.

3.2.4 Researcher reflexivity

In the sections above, I discussed my philosophical position regarding my research. Researchers can never be entirely separated from their research, particularly when doing interpretive research. *Reflexivity*, according to Schwartz-Shea and Yanow (2012), refers to the active consideration of the way in which the researcher's sense-making throughout the research process relates to the produced knowledge claims.

According to Cohen, Manion and Morrison (2007), acknowledging these interactions within all phases of the research process raises not only the awareness of the researcher, but also that of the reader of the study. In line with Morrow (2005), I employed reflexivity as a tool to enhance the rigour and trustworthiness of my interpretivist study (see Section 3.8). Morrow (2005) describes a reflexive strategy that assists the researcher in becoming aware of assumptions and biases, consisting of critical conversations with knowledgeable critical friends. I was fortunate in having such a critical friend, who served as a supportive, yet critical *mirror* and challenged me to articulate and clarify my thoughts throughout the entire research process of the current study. In accordance with McNiff's (2013) suggestions, I asked my critical friend to examine parts of my data, which led to in-depth discussions about the interpretation of the data, resulting in a deeper understanding of the outcomes of the study.

Schwartz-Shea and Yanow (2012) argue that the function of reflexivity varies during the various phases of the research process. Initially researchers should consider how specific personal, cultural, demographic and disciplinary characteristics might impact their study. For example, my foreigner status as a Dutch researcher in Scotland afforded me the freedom to ask many questions about Scottish school practices and the use of language, helping me become more aware of unspoken rules and customs. At the same time, it also impacted access to teachers as I had not yet built a network of teachers interested in and supportive of my study. During fieldwork it is important for researchers to reflect on researcher-participant interactions. The need for reflexivity remains essential during the analysis phase and the consecutive phase of publishing and presenting the findings of the study. As Merriam and Tisdell (2016) point out, the clarification of the researcher's assumptions, world view and experiences allow a reader to better understand the researcher's interpretation of the data. In addition, Probst and Beronson (2014) argue that it is important that researchers are aware, not only of the influence they have on what they are researching, but also how the research process in turn affects the researchers. The more I became aware of the conditional language aspects of the teacher's interaction with the children, the more I became aware of my own use of conditional language. This significantly influenced the language I used in discussing my own research and also affected the feedback given to me by my supervisors.

Over the years I had acquired experience doing research and considerable knowledge about environmental education. However, I had never stood in front of a primary school class. *Stranger-ness* or being an *outsider* refers, according to Schwartz-Shea and Yanow (2012), to researchers who, are not a member of the group they are studying and who therefore, are not limited by what is taken-for-granted and the common sense of what is familiar in a particular setting. Being an outsider made me more open to the power of surprise. This may well have been a factor in the discovery of the teachers' use of conditional language while teaching about complex sustainability challenges. In this respect, my interest in learning for sustainability and primary education, in association with the lack of a teaching degree, can be seen as an asset.

I have felt drawn to the field of education for many years, with a specific concern for learning for sustainability. I enjoy working together with teachers helping them become more aware of their teaching practice, developing new ideas together and feeling inspired by their enthusiasm and creative teaching approaches. This corresponds with the views of action research scholars such as Kember et al. (1997) and McNiff (2013), who describe the researcher as a critical friend providing the teachers with new ideas for developing their teaching practice. As a result, the teacher interviews became conversations in which we explored together what had taken place during the observed lesson and what we could both learn from it.

3.3 Research design

I considered several potential research designs for carrying out an investigation focused on my research questions (Schwartz-Shea & Yanow, 2012). My principal research question focuses on finding effective strategies for teaching children how to manage complex and contradictory information. Initially I wanted to observe an existing sustainability lesson, then make some adaptations and observe the lesson again, with the aim of testing the effect of particular teaching strategies. I considered employing action research, which Pine (2009) describes as "a nonlinear, recursive, cyclical process of study designed to achieve concrete change in a specific situation, context, or work setting to improve teaching/learning" (p. 4). However, I soon realised my study could not take the shape of a classical action research study as this, according to McNiff (2013), generally involves the practitioners themselves (in my case the teachers) enquiring "by the self into the self" (p. 23). And although I ended up collaborating with teachers who were interested in my research topic and were willing to welcome me into their classrooms, the research questions were my questions and I did the data collection and analysis myself. In addition, and perhaps more importantly, after discussing the research design with my supervisors as well as with my first year progression board examiners, I concluded that it would be better to focus on how Scottish primary teachers currently teach about complex and contradictory topics before attempting to implement changes.

It was then necessary to find a suitable research design that had the power to afford rich descriptions of the different approaches teachers take, as well as being conducive to interpreting the experience of both teachers and children. According to many researchers, case studies have the ability to provide rich, in-depth and holistic pictures drawing on a selection of data collection methods, various data sources and a variety of perspectives (Gillham, 2000; Flyvbjerg, 2001; Cohen, Manion & Morrison, 2007; Baxter & Jack, 2008; Yin, 2009; Hamilton & Corbett-Whittier, 2013; Abma & Stake, 2014). Flyvbjerg (2001) states that it is "the closeness of the case study to real-life situations and its multiple wealth of details" (p. 72) that make it so valuable for developing a more nuanced understanding of reality. In addition, Flyvbjerg (2001) maintains that case studies provide the opportunity to test ideas "directly in relation to phenomena as they unfold in practice" (p. 82), which often results in researchers dismissing preconceived theories and propositions. What a case study design loses in scope and breadth, it gains in depth.

3.3.1 Case study design

Stake (2005) argues that conducting a case study is not a choice for particular data collection methods, but rather a choice concerning what the focus of the study will be. One of the essential steps in designing a case study involves defining what is meant by this focus or in other words *the case*. Multiple scholars have tried to define what they consider to be a case (Cohen, Manion & Morrison, 2007; Gillham, 2000; Hamilton & Corbett-Whittier, 2013; Stake, 1995; 2013; Yin, 2009). Several characteristics stand out as they are mentioned in many of the various definitions, albeit in different words. For example, a case can be described as a unit of complex human activity centred in a real-world context with often blurred boundaries (Gillham, 2000); this unit can consist of an individual, a group of individuals, an event or an entity (Yin, 2009). Stake (1995) disagrees in part with Yin. Stake views a case as a system and therefore does not consider an event equally suitable as the focus of a case study. In the context of education, the case can, for example, consist of a teacher, student, a classroom or school. Yin (2009) further suggests that it is preferable to specify temporal boundaries that demarcate the beginning and the end of a case, as well as spatial, and other concrete boundaries. Yin does caution that defining a case(s) should not be seen as a permanent decision as it can be revisited as a result of insights gained during the data collection phase. What becomes clear from these definitions is the importance of, but also the tension that often exists in, defining the boundaries of a case.

In my study a case has been defined as a P6 or P7 classroom with a teacher and his/her children observed one, two or three times during (a) lesson(s) about a sustainability challenge such as anthropogenic global climate change or building dams and including a subsequent focus group interview with a group of children selected by the teacher, followed by an interview with the teacher. The data collection took place between the beginning of January and the end of June 2016. The boundary seems clear at first, but when looked at more closely, can become somewhat more arbitrary. For example, in my study one teacher collaborated with a colleague during the observed lesson without informing me of this beforehand. Some of the children switched between classrooms for part of the lesson. As a result, I had no consent from parents to record children in the second classroom and therefore did not include that classroom in my study, even though the teaching strategy included the actions of the second teacher.

While a case should be understood contextually, what happens outside the formal boundaries of the case (e.g. the classroom) may also be of relevance. Features from outside that can influence the case under investigation include “the physical, social, historical, sometimes political, ethical, and aesthetic contexts" (Abma & Stake, 2014; p. 1151). For example, the activities and opinions of other teachers within a particular school, as well as the wider societal and political context of Scottish primary education during the period (2014-2017), could potentially influence the participating teachers. An important policy programme influencing the practice of teachers during the study was the Curriculum for Excellence (Scottish Executive, 2004). This Scottish policy document was included in the data analysis and the interpretation of the case studies. See Chapter 1 for more details concerning the context of this study.

In summary, a case is a bounded—even if blurry at times— unit of human activity which is studied in great detail, providing a rich description and analysis of that unit within a particular place and a specific time frame. Defining the boundaries of the case helps determine the scope of the data collection and as Yin (2009) elucidates, it supports the researcher in distinguishing data that pertains to the focus of the study from data that forms the context surrounding the case. Having clarified what a case is and why defining the boundary is so important, the next step is to determine how many cases will be investigated.

3.3.2 Multiple case study design

A multiple case study design was selected in order to arrive at a clearer understanding of different teaching strategies already used by teachers in the upper primary years when teaching about complex and uncertain topics. Baxter and Jack (2008) explain that the aim of a multiple case study is to "explore differences within and between cases" (p. 548) and create a detailed contextual analysis. Hamilton and Corbett-Whittier (2013) divide case study designs into two types: intrinsic and instrumental. According to various scholars (Baxter & Jack, 2008; Hamilton & Corbett-Whittier, 2013; Stake 1995) an *intrinsic case study* is focused on capturing the entirety of that case in order to come to a better understanding of it; an *instrumental case study* focuses on a particular facet or issue of the case or facilitates the refinement of a theory. According to Baxter and Jack (2008), in an instrumental case study "the case is of secondary interest; it plays a supportive role, facilitating our understanding of something else" (p. 549). As the purpose of my research is to gain more insight into a particular aspect of the case, namely the process of teaching uncertainty competences in P6/P7 classrooms in Scotland, it comprises multiple instrumental cases.

Yin (2009) suggests a process called "analytic generalization" (p. 38) that describes how developing a predetermined theoretical framework to structure the investigation of multiple cases can lead to generalising the case study results. Even though I focused on the differences and similarities between those cases, I consider the number of cases (five) that I studied in-depth to be far too few to be generalisable. In addition, I did not set out with a narrow theoretical framework, as I found it of importance to remain open to and mindful of surprising and unanticipated discoveries during the observations (see Section 3.2.4). I was guided by Stake (2000), who takes a naturalistic approach, focusing on the particularities of cases and the mechanism of an event in a particular setting. I do not claim that the findings include everything that might have been found if a much larger number of cases were to be studied; nonetheless, exploring fewer cases in great detail certainly led to a better understanding of teaching uncertainty competences. The next section provides more detail about how the cases were selected.

3.4 Case selection, sampling and generalisability

3.4.1 Case selection

I employed *non-random purposeful sampling* for selecting classrooms. This approach maximises the information that can be extracted from small samples and individual cases and fits in with an interpretive research approach. Random sampling suggests that it is possible to compile a list of the entire research population and by randomly selecting cases avoid systematic biases in the sample. It was not possible for me to construct a list of all the Scottish P6/P7 teachers that actually taught sustainability topics with a focus on complexity and contradiction in advance. In any event random sampling better suits a positivistic research approach that aims at generalisability rather than focusing on the particularities of cases (Abma & Stake, 2014). Flyvbjerg (2001) discusses four types of "information-oriented selection" (p. 79). He states that cases can be selected on the basis of being: (1) unusual or deviant, (2) provide maximum variation, (3) critical (permitting logical deduction; if this is/is not valid for this case, then it is valid to all/no cases), and (4) paradigmatic (useful for developing a metaphor). As my main research question focuses on the teaching strategies that teachers are currently using, I wanted to find a small selection of cases that would maximise the variation in my data. For example, I expected teachers to have different views on teaching about contradictory sustainability topics and therefore expected them to employ different strategies. I therefore sought cases that were sufficiently different from each other. In initial talks with teachers I tried to get a sense of the teachers' level of genuine interest in teaching about sustainability topics and their views on teaching about complex and uncertain topics, without giving too much away regarding the focus of my research. If the teacher consented to participate in the study, we discussed by phone some of the ideas the teacher had for the lesson.

The number of cases would ideally be based on theoretical saturation. Saturation occurs when no new data is found that adds to theory development (Glaser & Strauss, 1967; Creswell, 2007; Cohen, Manion & Morrison, 2007). However, in practice case selection was shaped by a combination of searching for information richness, access issues and time constraints. The selection was heavily dictated by the practical criteria mentioned in Table 3.1 below:

- The school is in Scotland.
- It is a P6, P6/P7 or P7 class (denoted as upper primary years in Scotland).
- Teacher agrees to give 1, 2 or 3 lessons about a self-selected sustainability issue, using teaching strategies (s)he finds appropriate for teaching a complex topic.
- Teacher is interested in the study and feels comfortable being observed.
- Parents' consent to my observations and audio recordings in the classroom.

Table 3.1: Case selection criteria

3.4.2 Sampling – study population

My focus is on Scottish primary schools. Scotland is undergoing some interesting and progressive policy developments with regard to education for sustainable development (Higgins & Christie, 2018; Learning for Sustainability National Implementation Group, 2016; One Planet Schools Working Group, 2012; Scottish Executive, 2004; Scottish Government, 2013). In 2004 Curriculum for Excellence (Scottish Executive, 2004) was published. This policy intended to provide education that would prepare learners between three and 18 years of age for the 21st Century. The Scottish government aimed and continues to aim at transforming the more content-driven curriculum into curriculum that sets out to develop a more balanced acquisition of knowledge, skills and attributes. For my case studies I was searching for teachers who are moving toward a teaching process that includes teaching about complex and contradictory topics where there are multiple right answers. Within the setting of Scottish education, I chose to focus on the upper classes of primary schools. Although this in part related to my experience and personal interest with developing educational programmes for children of this age group, there is a more independent twofold rationale behind focusing on P6/P7 teachers that considers the children's cognitive and social development, as well as confrontation with complex environmental topics in the daily life of this age group (see Section 1.3.3).

3.4.3 Study sample: Five Scottish primary classrooms

The next step was to select the specific cases for my study. Finding enough teachers who are interested in a study and willing to be extensively involved is notoriously difficult. Initially I was thinking of about eight schools, with the intention of ending up with at least four or five strong case studies. This was partially in consideration of the reality that teachers sometimes pull out at the last minute or other factors diminish the quality of the data collection, such as unexpected events in the school or community. According to Flyvbjerg (2001), three or four "maximum variation cases" (p. 79) are sufficient as long as they are clearly different on one dimension; in this case that dimension consisted of the teaching strategies the teacher employed for the observed lesson. I continued searching for new teachers until I felt I had achieved the necessary variation.

The schools were approached through networks of teachers interested in learning for sustainability, who were therefore expected to be potentially open to giving a lesson on a sustainability topic. Although a call for participants was spread through several mailing lists and digital newsletters, it was most effective to attend events where teachers congregated independent of my presence. Examples are the *International Storyline Conference* in Glasgow in 2014, the *Experiential Education* course as part of the University of Edinburgh MSc programme *Learning for Sustainability* in November 2015, Continuing Professional Development (CPD) courses, and in March

2016 the professional learning initiative *Connecting Classrooms* that offers primary and secondary teachers in Scotland the opportunity to develop their skills in relation to Learning for Sustainability. As Schwartz-Shea and Yanow (2012) point out, access to cases “may be contingent on the identity of the researcher” (p. 70). What worked best for me was to attend these gatherings and talk to teachers individually. Many teachers seemed interested in the research and it gave me the chance to explain more about it, but also to build a personal relationship with individual teachers and talk about education and sustainability in a broader sense. I found one additional teacher through *snowball sampling* or *chain sampling* (Cohen, Manion & Morrison, 2007; Emmel, 2014), in other words asking the participating teachers if they could recruit a colleague who qualified for inclusion in the study and was willing to take part in the project.

I had originally intended to study the Global Storyline method (McNaughton, 2014) to see if this teaching approach provided teachers with good teaching strategies for teaching about complex and contradictory information. Global Storylines are based on the Storyline method developed by Steve Bell (Bell, Harkness & White, 2007), but include more drama lessons than the original storylines. Also, the topics in Global storylines always focus on sustainability issues. In practice it turned out not to be possible to study Global Storyline classrooms in combination with other classrooms. (Global) storylines can involve many lessons over weeks and even months as long as there is *learning energy* in the classroom. For practical reasons, I could only visit a classroom for a maximum of three lessons; this would mean that I would miss too many of the lessons, whereas the strength of (global) storyline springs from the entire story as it develops through actions and decisions of teacher and children (McNaughton, 2014). It seemed therefore that studying (global) storylines would be better served by doing an ethnographic study in which one classroom is studied in-depth during the entire storyline.

The five teachers who agreed to participate in my research were sent an email with a more elaborate explanation of the project, including a project information sheet (see Appendix A) and consent forms for parents or guardians and teachers (see Appendix B). In total 133 children obtained consent from their parents or guardians to participate in my study. The teachers were asked if they wanted me to approach the head teacher myself to ask permission for my research study, or if they would rather do this themselves. In the end all of them informed the head teacher themselves. The teachers considered the observed lesson to be an extra lesson or lessons rather than a formal part of the curriculum that they had to teach and assess.

Below, the reader will find concise descriptions of the five Scottish primary school classrooms in the order that I observed them. In Appendix C there are more elaborate descriptions of the schools, the teachers and what the teachers and children actually did during the lessons. These rich descriptions may be helpful for placing the findings in the findings chapters into context.

Classroom A (P7) – Global warming
The first school I visited was located in an agricultural town in the Scottish Borders. The teacher had been teaching for 18 years, usually P6 classes. This year she was teaching her first P7 class with 28 children. The teacher expressed an interest in teaching environmental education, but did not feel confident about teaching complex sustainability topics. She struggled to find time for these topics. The observed one-hour lesson took place on January 13th, 2016. The learning objectives were for the children to acquire basic knowledge about global warming and to be able to link this global issue to local experiences. The lesson included small group discussions, classroom discussions and a PowerPoint presentation.

Case B (P6) – Building dams
The second school was located in the Falkirk area and was an Eco-School. The teacher had been teaching for eight and half years, all at the same school. This year's class of 30 children was her first P6 class and she had not taught a P7 class. The teacher expressed an interest in teaching sustainability topics and in drama lessons. She and her colleague worked together in a Global Storyline project. Initially, I was going to observe three lessons in this Storyline, but in the end only the second observation proved to be of use. This two-hour lesson took place on March 3rd, 2016. The learning objectives were to acquire knowledge of dams and their purpose, to know some of the advantages and the disadvantages of dams, and to be able to hold a debate about building dams. The lesson included small group discussions, classroom discussions, PowerPoint presentation, video, note taking, making posters and a classroom debate.

Classroom C (P7) – Renewable energy
The third observation took place in the same school in the Scottish Borders as classroom A. The teacher had been teaching for 25 years, most of which at this school with a few years as a supply teacher elsewhere. She taught P6 and P7 classes for about seven years. This year she had a P7 class with 28 children. We agreed that I would observe 3 science lessons which took place on April 28th, and May 5th and 10th, 2016. In a pre-lesson the children chose what the topic would be. The learning objectives were to be able to discuss the principal ideas behind the complex scientific issue of renewable energy in general and wind energy in Scotland in particular. The teacher responded to emergent themes; as a result, the second and third lessons were focused on the death of the sun and the importance of birds for the world. The children had to research the topics in small groups and back their opinions up with scientific evidence. They created PowerPoint presentations which they shared with the class during a lesson that I did not observe. The lesson included small group discussions, classroom discussions, worksheets, video, conducting research and making PowerPoint presentations.

Classroom D (P6) – Beaver reintroduction
The fourth observation took place in a school in West Lothian. The teacher had been teaching for six years. He had previously taught three P6 classes and no P7 classes. This year he had his fourth P6 class with 31 children. The observed lessons took place on the May 25th, 2016. It was part of a lager topic about Scotland the class had been working on. The topic was the reintroduction of beavers in Scotland. The learning objectives were to be able to use print and online sources to understand a controversial topic, to be able to use the information to back or refute arguments and to develop skills in listening and persuasive language. The lesson included classroom discussions, PowerPoint presentation, small group discussions, conducting research and a parliamentary debate. It was the second time the children had done such a debate.

Classroom E (P7) – Pollinators
The fifth observation took place in a school in the Highland Council. The teacher had been teaching for eight years. She had never taught a P6 class and her current P7 class of 16 children was her first. The observed lesson took place on the June 16^{th}, 2016 and was connected to the Polli:Nation project, a UK wide initiative supporting schools to turn their school grounds into pollinator friendly habitats. The learning objectives were to be able to explain that many plants need animals and insects for pollination, and to be able to describe the reproductive structure of a flower. The teacher mentioned that the children were restless because they had just spent three days at their new High school where they would be going after the summer. The lesson included classroom discussions, small group discussions, worksheets, crafts and presentations.

3.5 Research ethics

This section describes the ethical deliberations regarding my study. With ethics I refer to what Morrow and Richards (1996) call "a set of moral principles and rules of conduct" (p. 90) that protect the research participants from any harm or wrongdoing and promotes respect and fair treatment. My study was classified by the Moray House School of Education (MHSE) Ethics Committee as *non-problematic*, which refers to the minimal likelihood of physical or emotional risk to the participants. The data, gathered through audio recorded classroom observations and interviews with a focus on teaching how to manage complex and contradictory information regarding a sustainability topic, are not considered particularly *sensitive*. Nevertheless, since most participants were children under the age of 16, specific measures were taken to protect them.

3.5.1 Ethics of working with children

Vaughn, Schumm and Sinagub (1996) posit that children are generally perceived as being vulnerable when participating in research projects because of "their lack of social power" (p. 140), and it is therefore important to take this into account in the research design and adhere to the ethical guidelines of the relevant field during the development and the implementation of the study. I followed the British Educational Research Association (2011) ethical guidelines and presented my research plan to the MHSE ethics committee. As I was going to observe children age 10-12 and conduct focus group interviews with some of them, I arranged my Protecting Vulnerable Groups (PVG) application to Disclosure Scotland before visiting any schools.

The children in my study can be considered in Hart's (1992) words "assigned but informed" (p. 10) with regard to the research. This refers to the level of participation and autonomy the children experienced during my research and the four requirements for this level that were met. First, it meant that I communicated to the children what I intended to do with the research (improve the way in which teachers teach complex environmental issues) (Hart, 1992). Secondly, they knew I had asked the teacher if I could conduct observations and interviews in his/her classroom and that the teacher had agreed to this, as long as their parents/guardians agreed with it as well (Hart, 1992). I implemented an opt-in consent process which Shaw, Brady and Davey (2011) describe as involving asking the potential participants and their parents/guardians to give active consent, which in this study entailed signing a consent form. See Appendix A and B respectively, for the project information and the consent form that were provided to parents/guardians. In the original forms I used the word caregiver, but for reasons of consistency I have changed them all to guardian. The teacher explained that I would be visiting the classroom to do research and asked the children to give the consent form to their parents/guardians. The children had the opportunity to talk to the teacher if they were concerned about the study. They also had the chance to talk to their parents. Therefore, even though they didn't sign the form themselves, the children were given opportunities to voice their feelings and make their own decision. The third requirement that was met involved the children being allowed to say that they didn't want to be observed, recorded and/or interviewed even if their parents signed the consent form (Hart, 1992). I always asked the children, who were selected by the teacher (see Section 3.6.4), before starting the focus group interview if they were willing to participate. None objected. And finally, the fourth requirement involved the children having an important and meaningful role (Hart, 1992). I made clear from the start that observing the interaction between them and their teacher was essential to my study. In addition, talking to the children in the focus groups gave me the opportunity to find out how they experienced the lesson. Their views were essential to my study. At the end I thanked the children and the teacher for their contributions.

3.5.2 Ethics of collecting audio (visual) data and data storage

In this section I will address some issues of anonymity and confidentiality. A research participant is considered anonymous when the participant cannot be identified from the information provided by either the researcher or anyone else (Cohen, Manion & Morrison, 2007). Confidentiality, on the other hand, refers to the researcher being aware of who provided the information and/or being able to identify them from the collected data, while at the same time not sharing this connection in publications, presentations or other public communications (Cohen, Manion & Morrison, 2007). Unless, for example, anonymous questionnaires are used, anonymity cannot be ensured. Because I made use of observations and interviews I could only promise confidentiality.

Fieldwork took place in the second year of the PhD project. Although the topic was not considered to be especially sensitive, I followed the British Educational Research Association (2011) ethical guidelines regarding the management and storage of my research data. The classroom observations and interviews were recorded using voice recorders to ensure that relevant information was not lost. As Miles and Huberman (1994) stress, it is essential to have a clear storage and retrieval system to maintain an overview of the data collected during the course of the research project. Accordingly, I decided how I would store and label my data before beginning data collection (see Section 3.6). After the lessons and the interviews, I uploaded the seven audio recordings of the classroom observations, the five focus group interviews and the five interviews with the teachers to the secured university computer network to protect confidentiality. All the recordings were labelled to ensure that they were well organised and retrievable. Names of schools and teachers were not included in the labels. See Appendix D for the labelling system of the stored recordings.

The labelling made it easier to allow some of the interviews to be transcribed by an external organisation as it ensured confidentiality. Although the recordings did not contain especially sensitive data, confidentiality was agreed to with the participants, or their parents/guardians in the case of the children, in the consent forms they signed. Participants are given a pseudonym when findings are discussed in any written publication or presentation. Confidentiality was also facilitated by not asking the interviewees to state their full name or the name of the school on the recording. The transcripts were labelled in the same way as were the recordings and also uploaded to the secure university computer network. A hard copy was made for use during the analysis process. It was kept in a locked drawer in my office. Permission was asked on the consent forms for using anonymised pictures in educational publications, reports and presentations. A limited number of pictures were taken that showed the faces of participants. These were uploaded to the same pass-word protected computer system and saved without identifying personal data. All original data will be retained by the researcher throughout the study and for one year after completion when it will be destroyed.

3.6 Data collection

The research questions and the type of data required to find answers strongly influenced my choice for particular methods. As my focus was on the teacher and the teaching strategies that were employed, I decided to, what I call—*follow the trail of the teacher*— through the classroom and construct a narrative description of the interactions between the teacher and individual children, between the teacher and small groups or between the teacher and the entire class. This process can be compared to *shadowing*, an ethnographic data collection method, that according to Quinlan (2008), entails the "researcher closely following a subject over a period of time to investigate what people actually do in the course of their everyday lives" (p. 1482). Quinlan further explains that the focus lies on gathering data grounded in actual events rather than reconstructions after the fact, as is common in, for example, interviews. In fact, I decided to employ a combination of data collection methods that could capture both what was actually happening in the classroom during the observations as well as other methods that helped reconstruct the perspectives and experiences of the children and the teacher with respect to the observed lesson. The following six data sources were employed: classroom observations, focus group interviews with the children, interviews with the teacher, field notes, teaching resources and children's assignments.

3.6.1 Preparation data collection

The data collection methods were developed between September and December 2015 as is summarised in Table 3.2 below. I explored many different observation checklists such as the Chesterfield Classroom observation tools (1997), observation checklists from the Public Schools of North Carolina Foreign Language Project (1999), Observation checklist used for teacher-training and discussed in Richards and Farrell (2011), the lesson observation checklist of the Ofsted guidance to inspectors (Ofsted, 2012) and many more. Examining the lists helped me articulate my thought process regarding the specific classroom elements (e.g. teaching strategies, events, interactions, employed teaching materials and children's assignments) I wanted to explore and what their indicators might be. However, none of these lists appeared to be entirely relevant for my study. In the end, I decided to go back to my earlier theoretical work about teaching uncertainty competences and combine the elements that emerged from the observation checklists described above with those suggested by my model "Pathways for handling knowledge uncertainty" (Tauritz, 2012a, p. 303), my list of "uncertainty competences" (p. 94) and the list of "design principles for a pedagogy for uncertain times" (p. 97) in Tauritz (2016). These would become the elements forming the first version of the observation grids.

Preparation data collection	**Developing 1st & 2nd version observation grids** Test observation grids during trial, which led to the decision to make audio recordings instead.

Table 3.2: Preparation data collection

A trial classroom observation about a complex and uncertain topic (Israel-Gaza conflict) in a P7 classroom in December 2015 was used to test the observation grids as well as to develop the research protocols for the other data collection methods. During the trial I tested the first version of the 3-page long *Observation Grid – Teacher*, the 4-page *Observation Grid – Teaching Strategy* and the 4-page long O*bservation Grid – Learner*. It quickly became clear that it was not possible to capture all that was happening in the classroom and seemed relevant with respect to my research questions using the grids during the observation. See Appendix E for a selection from the first version of the 3-page long *Observation Grid – Teacher* used during the trial observation. In a subsequent attempt to construct a more viable observation grid I left out the indicators, reasoning that by this time I knew quite well what I meant by the different elements. I also simplified the language I used by rephrasing and shortening the elements, for example, *Does the teacher ask key questions?* became *Teacher asks key questions*. (See Appendix F for the adapted version of the selection presented in Appendix E.) I merged the observation grids and ended up with two grids: *Teacher and Teaching Strategy* and *Learner and Group*. However, as I wanted to maintain a wide perspective on what happened in the classroom, I did not shorten the grids any further and they continued to be too long to be useful as a practical observation tool. At this point I set the observation grids aside and considered recording the observed lessons instead.

3.6.2 Interpretive bricoleur

In the end I employed six different data collection methods, transcending the boundaries of a single research method approach to become what Denzin and Lincoln (2011) call an *interpretive bricoleur*, someone who employs a mixture of strategies and research methods with the aim of producing a bricolage: a rich representation of a complex situation. Using the cluster of data collection methods described in this section provided me with the opportunity to capture the differing perspectives of the children and the teacher in the classroom. The use of multiple data sources is important for another reason, namely for a process referred to as *triangulation* (see Section 3.8), which according to Morrow (2005) contributes to the *trustworthiness* of the conclusions. The data collection took place between January and the end of June of 2016. The six sources (see Table 3.3) will each be discussed separately in the following sections.

Data collection	**Audio recordings**	**Field notes**	**Teaching resources**	**Children's assignments**
	Classroom observations Focus group interviews Teacher interviews	Descriptive Analytic Methodological Reflective	PowerPoint Video Information sheets Books	Poster PowerPoint

Table 3.3: Data sources

3.6.3 Audio recordings – following the trail of the teacher

After doing the trial observation equipped only with the first version of the observation grids (see Section 3.6.1), a notebook and a pencil, I came to the conclusion that doing observations without any audio (or visual) recordings was inadequate. I discovered that it was impossible to write down the language being used and the questions the teacher or the children asked without missing the answers that were given, let alone having time to note body language, tone of voice or classroom atmosphere. When the children were all talking at the same time in small groups it was impossible to make out what anyone said unless I stood right next to them. I was confronted with both a practical and an ethical dilemma concerning how to capture the interaction between the teacher and the children.

I had to decide if I needed to record the body language the children and teacher were exhibiting in detail, or if audio recordings alongside field notes made during the lessons would suffice. Cohen, Manion and Morrison (2007) suggest that audio-visual recordings have "the capacity for completeness of analysis and comprehensiveness" (p. 407) of the classroom interactions and could overcome certain issues, such as only recording events that occur frequently. On the other hand, Pirie (1996) counters this when she reminds the reader that all research is subjective to some degree and where we place the camera, which microphones are used and how we interpret the data can all have a limiting effect on comprehensiveness.

Video cameras have certain inherent limitations. For example, when internally complex activities are studied, using a single camera is probably insufficient (Derry, 2007). When the camera is fixed it provides only a limited view of the classroom, and even when it is not fixed the recording is still selective. In addition, using a camera can potentially create a problem of reactivity (Pirie, 1996; Cohen, Manion & Morrison, 2007; McNaughton, 2009). Also, according to Derry (2007) the audio recording quality of the built-in microphones found in cameras is generally insufficient in a classroom full of talking children, requiring additional microphones. Budget limitations regarding the recording equipment and the availability of equipment for loan through the Learning Spaces Technology (LST) unit of the University's Information Service were practical constraints in this study. Another concern was both practical and ethical, involving potential difficulties in obtaining complete ethical approval from the ethics committee because of the "non-anonymous nature of video" (p. 61) as well as considerations related to privacy and confidentiality (Derry, 2007).

Furthermore, I expected it to be more difficult to find teachers who were willing to be visually recorded and parents or guardians who would consent to their children being filmed. Audio recordings would be less intrusive and more easily accepted. I decided to test the use of audio recordings in a classroom.

Although obtaining approval from the MHSE Ethics Committee and getting consent from teachers and parents certainly seemed likely to be easier than for video recordings, the question of how to record the interactions between the teacher and the children remained a challenge. When many children are all talking at the same time in small discussion groups, discerning what individuals are saying can be difficult. As the teacher was the pivotal person in the classroom, I needed to be sure that I would be able to capture his or her voice. I employed a *lapel microphone*, also known as a tie clip microphone, for the teacher and a good quality audio recorder such as a H2 Zoom recorder as advised by the technicians from the LST unit and corroborated by the literature (Pérez-Parent, 2002; Derry, 2007). The quality of these recorders compared to the digital voice recorders usually used for interviews is considerably higher and very important for successful data gathering in a noisy classroom setting. It would have been ideal if I could have equipped each child or at least each child in the focus group with a tie clip microphone. However, as there was limited equipment available and I was allowed no more than one Lavalier microphone, one H2 Zoom (used for the teacher) and one H4N Zoom recorder (used for the focus group) by the LST unit, I needed to think of some other way to capture what the children were saying. I decided to provide each table group with a digital voice recorder. This meant that on average there were six recorders plus the teacher's recorder in use in the classroom. The H4N Zoom recorder was placed on the focus group's table because, according to the technicians, this would ensure the best recording of a group discussion in a noisy space. The digital recorders used for the rest of the table groups were borrowed from the Postgraduate department of MHSE.

Before the lesson, all the recorders were fitted with a piece of masking tape and a number that corresponded with the table number where each recorder was placed. A rough map of the classroom was drawn in my research journal. The teacher selected the children who would participate in the focus group interview and informed me, but not the children, which group they were at the start of the lesson. If the class set-up changed, for example when the children were seated in small groups, then moved to a big circle, and then moved back to the small groups, or even involved children moving through the classroom, a different approach was necessary. One child per group was made responsible for taking the recorder with them if the group moved. If they were walking through the classroom the recorders stayed on the tables. When relevant, a new map was drawn.

Although I always asked the teacher beforehand about the various configurations which might arise during the lesson, what actually happened was not always predictable. For example, there was the moment when a teacher, after doing a classroom debate with the children about beaver reintroduction in Scotland, asked the children to hand in the recorders and move the tables and chairs back and sit down. It seemed the lesson had ended. However, the teacher suddenly began asking the children questions such as *What did you learn during that lesson?* To me, that lesson hadn't ended at all. Luckily, the teacher was still wearing his mic and I started jotting down notes as fast as I could.

I realised it was very important to tell my teachers as much as possible about what I expected from the lesson, without telling too much about the content that I was focusing on. Wajnryb (1992) cautions that if teachers are alerted to the research focus this might influence, for example, the language they employ in the classroom and therefore contaminate the data. I explained that I wanted to observe which approaches teachers themselves used to tackle complex environmental issues. In addition, I said that I wanted to observe a lesson in which the children were confronted with contradictory information regarding an environmental issue and were encouraged to consider who or what to believe, or were asked to make a decision on what to do about the issue. As a researcher, my perspective on what was potentially important for the study was not always evident to the teacher and therefore required a certain amount of clarification on my part. This concerned in particular issues of classroom management and organisation and took place during initial talks with the teacher (see Section 3.4.1). At the start of each lesson I gave a brief explanation about the research and the use of the recorders, after which I turned them on and the teacher commenced with the lesson.

I usually sat in the back of the class making scratch notes and tried to be as unobtrusive as possible. When the children were all discussing in their table groups, I could not make out what they were saying unless I was actually standing next to a group. During the analysis I therefore relied heavily on the recordings of these discussions (see Section 3.7).

I recorded seven classroom observations. Although, as Madden (2010) rightfully states, the recordings captured "the content and tone of the verbal exchanges" (p. 132), they could not capture elements such as body language, my perception of the participants' feelings and the classroom atmosphere. A different method was required to capture these elements of the lesson.

3.6.4 Field notes

The second data collection method I employed was the use of field notes. Schwartz-Shea and Yanow (2012) point out that field notes form the backbone of interpretive research because of their importance in being "transparent" (p. 89) and creating "scientific systematicity" (p. 89) in the research process. It is also a way of tracking changes made to the research design resulting from experiences and practicalities in the field. The field notes are the expanded version of what are sometimes referred to by Bernard (2006) as *scratch notes* or *field jottings* (p. 389) that are written down throughout the observation. Although the term *field notes* seems to imply that these notes are only made while doing data collection in the field, and though most of this subsection focuses on such notes, they can be made throughout the entire research process. I jotted down many notes in my journal while working in the office; some researchers refer to this as *memoing* (Cohen, Manion and Morrison, 2007). I employed four types of field notes in order to capture in Hamilton and Corbett-Wittier's (2013) words, the "aspects of context, interesting interactions and reflections on experiences within fieldwork" (p. 96). In addition, I recorded relevant thoughts during desk work, and during conversations I had with colleagues and supervisors (Schwartz-Shea and Yanow, 2012). The field notes included *descriptive notes* (observation), *analytic notes* (interpretation), *methodological notes* (reflection on research choices) and *reflective notes* (feelings and experiences) (Bernard, 2006).

Before the observations I met the children and sometimes observed the class during the lesson or activity that took place prior to the lesson I had come to observe. I did not take notes during that time so that the class could get used to my presence. During the actual classroom observation, I immersed myself in the lesson, observing and recording as much as possible. The atmosphere in the classroom was briefly described from my perspective as researcher. This formed the classroom context for analysing and interpreting the diverse interactions. Following from my research questions, the emphasis of the observations lay on the interactions between the teacher and the class as whole, the teacher and small groups, and the teacher and individual children. I initially observed the interaction within the focus group when the children were working in groups, but as the children seemed very aware of being watched, I decided to distribute my attention more evenly over all groups. While observing the teacher interacting with the focus group, I tried to alternate between observing the focus group and the rest of the class to see what was happening at that moment from a more holistic perspective. Observing the children and making scratch notes in real time provided information on aspects of the interactions that could not be distilled from the recordings alone (Madden, 2010). Some examples include: *children are attentive, children display signs of distress, children are looking worried, children avoid eye contact with other children or with the teacher, children display signs of boredom, children are distracted, children look tired, yawn and seem to show a lack of interest, children are impatient*. I used this method to support the findings distilled from the recordings.

The scratch notes were sometimes discussed with the teacher to check interpretations of particular happenings in the classroom. This is a form of “member checking” (p. 1802) which, according to Birt, Scott, Cavers, Campbell and Walter (2016), entails asking the participants (in this case the teachers) to check the data or findings for accuracy and resonance with their experiences (see Section 3.8). For example, a boy during a classroom discussion about wind turbines killing birds posed the questions *Why would anyone care if birds died anyway?* and *What do birds do for the world?* It sent an emotional shock wave through the classroom and I discussed immediately after the lesson with the teacher what had transpired. This might not seem important at first glance, but the teacher actually changed her lesson plan for the following lessons in order to delve deeper into this issue with the children. If I had not checked in with the teacher I would have missed the many layers of social interaction that had taken place. The same teacher told me that certain children had a dominating effect on their peers which influenced the safety of the learning environment, something that could be particularly important when talking about a controversial topic (see Section 2.5.2).

During the research process I compiled two research journals containing the four different sorts of field notes (Bernard, 2006) discussed at the beginning of this section. The recordings and the field notes captured what was happening in the classroom. However, for a more complete interpretation, it was also important to find out how the children had experienced the lesson.

3.6.5 Focus group interviews with children

The third data collection method consisted of conducting focus group interviews with children from each classroom. It was important to me for several reasons to hear from the children themselves how they had experienced the lessons. First, I was interested in the interactions between the teacher and the children and therefore wanted to collect both their perspectives. According to Schwartz-Shea and Yanow (2012) this fits in with a methodology that is informed by interpretive presuppositions and acknowledges that the individual children and the teacher will have both valuable and different experiences of the same lesson. Second, in Section 2.5.2 learning environments conducive to developing uncertainty competences were discussed and it was suggested by Tauritz (2016) that *making uncertainty negotiable in the learning* process is essential for learning how to manage knowledge uncertainty. This entails making uncertainty visible in the learning process and discussing it explicitly (Forrest et al., 2012; Hall, 2010). I wanted to know if the children experienced any knowledge uncertainty during the lesson due to the complex, uncertain and controversial nature of the topic.

The focus groups each contained four or five children, as the literature (Vaughn, Schumm & Sinagub, 1996; Greig, Taylor & MacKay, 2007) suggests that this is a good number of participants for this age group. The teacher selected the children after I suggested that the groups should contain both boys and girls with a range in abilities.

Focus group interviews, according to Greene and Hogan (2005), have several advantages over individual interviews when interviewing children. They can create a safe peer environment, are similar to the small group setting in which children often work in schools nowadays, and they may also redress the power imbalance between adult and child which is inherent to one-to-one interviews. Further, children may be encouraged to give their opinion when they hear their peers do so, and their memory may be jogged by listening to the others responding. This method acknowledges the child as expert (Greene & Hogan, 2005). The downside of this form of interviewing according to Greene and Hogan (2005), is that the children are being asked to share personal opinions and experiences with other children present, which can be experienced as stressful, and some sensitive topics may not be suitable. This did not seem to be the case in the present study. The children were asked at the start of the interview if they wanted to participate (see Section 3.5.1). They all agreed to take part.

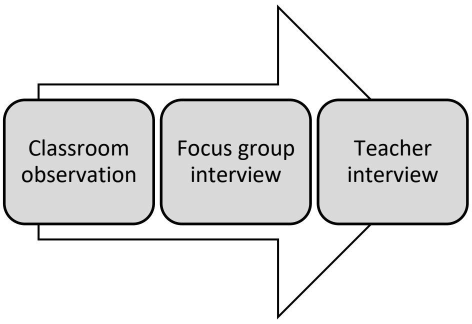

Figure 3.1: Three audio recordings per case study

The focus group interviews were held soon after the observed lessons took place, while they were still fresh in the children's minds, though sufficient time was needed to listen and at least partially transcribe the recordings of the classroom observations first. In addition, the field notes, the teaching resources and the children's assignments were reviewed to see what stood out in the lesson (see Table 3.4). Preliminary analysis took place throughout the data collection period and will be further discussed in Section 3.7. In each classroom observation of a lesson or lessons preceded and informed the focus group interview that took place soon thereafter, and which in turn informed the teacher interview that followed on the focus group interview (see Figure 3.1).

Preliminary analysis during data collection	**Listen to recordings, read fieldnotes, examine teaching resources & children's assignments** whilst looking for what stood out and what surprised me

Table 3.4: Preliminary analysis during data collection

I usually returned to the school in the week following my classroom observation. At the start of the fieldwork I developed a list of initial focus group questions (see Appendix G) which I adapted with the observation in mind while preparing for the interview. This resulted in a semi-structured interview guide. This type of interview is, according to DiCocco-Bloom and Crabtree (2006), the most universally employed interview format in qualitative research; this format includes "open-ended questions, with other questions emerging from the dialogue between interviewers and interviewees" (p. 315). I remained open to potentially relevant topics that the children brought into the conversation. Although I requested a quiet room to conduct the focus group interviews, there were occasions on which such a room was not available, and we sat in a space where people passing by caused minor distractions. The interviews took on average 30-45 minutes, which is within the maximum recommended in the literature (Vaughn, Schumm & Sinagub, 1996; Gibson, 2007).

The focus group interviews provided interesting discussions and insights into the children's experiences of the lesson. However, it was also important to find out how the lesson had transpired from the teacher's perspective.

3.6.6 Interviews with teachers

The fourth data collection method I used consisted of an in-depth semi-structured interview with each teacher conducted after the focus group interview had taken place. A question central to my research focuses on the teaching strategies that Scottish teachers are currently using when discussing complex and controversial topics in P6/P7 classes. Initially I offered the teachers only a brief explanation of my study to avoid undue influence caused by awareness of my research focus (Wajnryb, 1992). After observing the teachers in the classroom, I wanted to examine the motives and ideas behind the choices they made to employ particular strategies and find out how they had experienced teaching the lesson. I also wanted to know more about their views and assumptions regarding the relevance of teaching about complex, uncertain and contradictory topics to children in the age-group 10-12. Cohen, Manion and

Morrison (2007) assert that semi-structured qualitative interviews can be used to probe the interviewee; in this case that meant gathering data about the teacher's values, assumptions and beliefs regarding his or her teaching practice.

I asked the teachers to respond to my observations as to what the children said in the focus group. After I had listened to and at least partially transcribed the focus group interview with the children, the list of initial teacher interview questions (see Appendix H) was adapted in preparation for the interview. An example of an adapted question suggested by the focus group interview was: "Were you aware that some of the children went home thinking about beaver reintroduction and found it so hard to believe what you said about there being no beavers in Scotland that they looked on Google as soon as they got home to check this?" These adaptations resulted in a semi-structured interview guide with open-ended questions. I remained open to potentially relevant topics the teacher might bring into the conversation. The interviews took place either at the school, or online using VoIP (Voice over Internet Protocol) technologies such as Skype and Facetime. Lo Iacono, Symonds and Brown (2016) suggest that these applications offer flexibility with regard to the time and place of interviews while, in contrast to phone calls, allowing for the exchange of non-verbal communication such as facial expression comparable to face-to-face interviews. The length of the conversations was approximately 45-60 minutes. I asked the teachers if they would like to receive a summary of the results at the end of the research project, which they all confirmed.

The recordings of the five teacher interviews were stored safely and transcribed for further analysis (see Section 3.5.2 and Section 3.7). Although the audio recordings also captured the spoken elements of videos the teachers employed, other resources, such as information sheets and PowerPoints were not captured by the recordings or the field notes.

3.6.7 Teaching resources

My fifth source of data was the teaching resources or teaching materials the teachers used for the lessons (Kyriacou, 1998). These included videos, PowerPoint presentations, information sheets, websites and instructions for tasks and assignments.

During the data analysis it became evident that the selection or development of particular teaching resources is an important element of the teaching strategy the teachers employ to achieve their learning objectives (see Section 4.6). Aspects of the resources that particularly interested me were the use of absolute or unconditional language versus conditional language (Langer et al., 1989) and the presence or absence of contradictory perspectives and knowledge uncertainty (Tauritz, 2016). I received copies of the information sheets and instructions during or just after the lessons. I looked at the books that were used and made some pictures of pages the children were using during the lessons. I noted the websites that were used and studied them after the lessons. During the interviews with the teachers I asked them what their reasons were for selecting a particular video, book or website as part of their teaching strategy. In fact, the in-depth interviews with the children and the teachers were crucial for understanding the phenomenon of teaching uncertainty competences. I was interested to see what evidence I could find regarding the impact of the teacher's strategies on the children's learning. In addition, to the focus-group interviews I examined the children's assignments.

3.6.8 Children's assignments

My sixth and final data source consisted of the assignments the children were given in some classrooms. Examples include making posters with arguments for a debate about dams, art-work integrating complex knowledge about pollination and PowerPoint presentations presenting the results of the children's research about the dying of the sun. During the data collection and preliminary analysis, I became particularly interested in the children's use of conditional and unconditional language, how this related to the teacher's use of language and whether or not knowledge uncertainty had been present during the lesson. One teacher encouraged the children to ask lots of questions and to challenge the legitimacy of knowledge sources and the certainty of information. I was curious to see what, if any, of these issues were found back in the children's assignments (see Chapters 4-8).

3.7 Data analysis

In the previous section I discussed the six data collection methods that I employed during the fieldwork phase. In this section I will discuss the data analysis approach taken with respect to the various data sources. In Section 3.6 I described how observation grids for classroom observations were developed during the preparatory phase of the data collection. Although I decided against employing the grids in the classroom, I converted them during the preliminary analysis phase, discussed in Section 3.7.1, into audio recording grids. I then used them as an initial analysis tool for the recordings of the classroom observations, the focus groups, and the teacher interviews. Section 3.7.2 focuses on transcribing the recordings, thereby preparing the data for further analysis. In Section 3.7.3 I describe employing interpretive content analysis and the 1st coding cycle which included both developing and further refining the coding analytical framework and coding all the data sources. During this 1st coding cycle I analysed the six data sources for each classroom, creating a first picture of interactions between the teacher and the children on a classroom level, before moving on to the next classroom. During this phase of the analysis categories emerged that grouped related codes according to what was happening in the classroom. It became increasingly clear how important the use of unconditional and conditional language was in this study. During the 2nd coding cycle, described in Section 3.7.4, I focused on how the key elements of the teaching strategy were employed to teach about a complex and uncertain topic, and consequently which opportunities were created for the development of uncertainty competences. The themes that emerged at this time form the basis of the findings chapters. A special focal point was the use of language and questions. Equipped with more knowledge of the different forms conditional language can take and new codes about classroom questioning, I recoded the transcripts of the classroom observations. This led to the new concept *language of conditionality* introduced in Chapter 6.

3.7.1 Preliminary analysis during data collection

The data collection and the preliminary analysis occurred alternately (see Section 3.6.5). The classroom observation grids were adapted and transformed into an analytical tool that I could use for a preliminary interrogation of the recordings in preparation for the focus group interviews and the teacher interviews. I removed the column for tally marks, as number of occurrences of particular classroom interactions did not seem informative, and renamed the grids *audio recording* grids.

After each classroom observation session I organised my field notes and listened to the recording of the classroom observation. When possible, I transcribed selections of the recordings; there was rarely enough time to transcribe the whole recording at this stage (see Section 3.7.2 on the transcribing process). The next step was to make use of these *audio recording grids* to select the striking issues that should be explored during the focus group interviews. One example is something a child had said to the teacher at the end of the lesson in Classroom B, where the children debated the advantages and disadvantages of dams. The child said that he was glad he didn't have the job of the person having to decide to build or not build a dam because of the potentially negative consequences for people and the environment. During the focus group interview I asked the children what they thought about such a job and an interesting conversation ensued about the skills the children thought were necessary to make such decisions and what the role of schools was in developing the necessary uncertainty competences. After the focus group interview I listened to the recording, organised my field notes, and transcribed part of the recording, this time in preparation for the interview with the teacher. Again, I employed the *audio recording grids* to discover which issues had arisen that would be of value to explore with the teacher. Another interesting example comes from classroom B. Some of the children shared with me during the focus group interview that they had thought about the question concerning whether they were for or against building dams for days. I asked the teacher if she had been aware of the confusion the children had experienced during the debate and the days that followed. She had not been aware of this and it led to further interesting discussion.

Preparation data collection	**Developing 1st & 2nd version observation grids** Test observation grids during trial, which led to the decision to make audio recordings instead.			
Data collection	**Audio recordings** Classroom observations Focus group interviews Teacher interviews	**Field notes** Descriptive Analytic Methodological Reflective	**Teaching resources** PowerPoint Video Information sheets Books	**Children's assignments** Poster PowerPoint
Preliminary analysis during data collection	**Listen to recording (audio recording grids), check fieldnotes, teaching resources & assignments** whilst looking for what stood out and what surprised me			
Data preparation	**Transcriptions**			

Table 3.5: Data preparation for data analysis

3.7.2 Data preparation and data reduction

The next step after having collected all my data was to complete the transcriptions of the recordings (see Table 3.5 above). I had audio recordings of three kinds, from the classroom observations, focus group interviews and teacher interviews (see Figure 3.2). They were all transcribed line-by-line employing “intelligent verbatim transcription” (p. 17), which, according to Hadley (2015), is a type of transcription that stays true to what participants have said, but without reproducing “every filler word, hesitation and false start” (p. 18). Although some linguistic meaning can be lost, it is much less taxing for the transcriber. In fact, with the audio recordings from the classroom observations it was often not possible to hear those aspects because of the noise level when all the children were speaking at the same time.

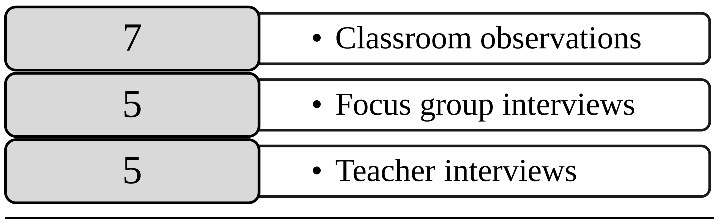

Figure 3.2: Overview audio recordings

Transcribing the audio recordings from the classroom observations therefore proved to be especially challenging. With on average seven recordings (six recorders on the tables and one recorder for the teacher) for each of the seven observed lessons, ranging from one to two hours in length, I had a massive amount of data. However, as I was following the trail of the teacher (see Section 3.6.3) I focused on transcribing the recording of the teacher and turned to the other recordings only when I could not make out what was being said between the teacher and the whole class, a small group or an individual child. I did transcribe conversations the children from the focus group had during the lesson. These exchanges served to supplement what I heard following the trail of the teacher and enriched the presentation of what was taking place in the classroom during the observation. I also included the teaching resources, such as transcriptions of the audio component of the video’s the class watched or the assignment sheets for small group work as a component of the trail of the teacher; I consider them to be part of the communication between the teacher and the children. Despite difficulties arising from the sheer quantity of recorded material alongside the degree of concentration needed to interpret what was said arising from the quality of the recording, a very interesting narrative containing valuable information started to appear. Due to time pressure some of the focus group and teacher interviews were transcribed by a professional transcriber. I carefully reviewed all the transcripts that had been outsourced while listening to the audio recordings, keeping in mind, as Bazeley (2013) rightfully states, words that are unintentionally omitted or wrongly heard can change the entire meaning of a sentence. Generally, there were only minor errors, often caused by the transcriber not being familiar with the background of the research and the context of the interview itself. I always did the transcriptions of the classroom observations myself, as this was a very challenging process.

To be able to make sense out of the data and to discern patterns, Ryan and Bernard (2000) stress the need to reduce the amount of data. It should be pointed out that decisions about what and how to record, and what and how to transcribe are interpretive acts that offer ways of reducing a large amount of data and making it more accessible, and were made with the intention to stay as true as possible to the participants' interaction. While transcribing the observed lessons, I occasionally further reduced the data by summarising those fragments of the observation that did not seem relevant to the study to save time (Stake, 1995). For example, I omitted a teacher's discussion with the children about properly shutting down laptops. Later when coding the data, the summaries reminded me why a particular fragment wasn't literally transcribed.

3.7.3 First Coding Cycle

During the next phase I performed interpretive content analysis, which is a systematic way of analysing the presence, and interpreting the meanings and relationships, of words and concepts in latent and manifest communications (Drisko & Maschi, 2015). Central were the development of the *coding analytical framework* and the use of *1st coding cycle* methods (see Table 3.6 below). At first it might seem odd to think that the data sources can be coded if the analysis tool to interrogate the data has not been finalised. However, in accordance with the premises of the hermeneutic circle and the abductive approach discussed in Section 3.2, I suggest that the coding and the development of the coding analytical framework cannot be entirely separated. The first iteration of the coding analytical framework was based on the audio recording grids developed and used during the preliminary analysis phase. The coding framework was further refined during the coding process in response to new emerging insights. During the 1st coding phase I focussed on what was happening in the interactions between teacher and children, which characteristics of a learning environment conducive to the development of uncertainty competences were evident in the observed lessons, and which strategies the teachers employed to teach about complex and uncertain topics per classroom.

Preparation data collection	**Developing 1st & 2nd version observation grids** Test observation grids during trial, which led to the decision to make audio recordings instead.			
Data collection	**Audio recordings** Classroom observations Focus group interviews Teacher interviews	**Field notes** Descriptive Analytic Methodological Reflective	**Teaching resources** PowerPoint Video Information sheets Books	**Children's assignments** Poster PowerPoint
Preliminary analysis during data collection	**Listen to recording (audio recording grids), check fieldnotes, teaching resources & assignments** whilst looking for what stood out and what surprised me			
Data preparation	**Transcriptions**			
Data analysis	**1st Coding Cycle – Interpretive Content Analysis** Coding Analytical Framework (12 categories, 72 codes)			

Table 3.6: 1st Coding Cycle and emerging categories

Coding Analytical Framework

I began this phase by reading all three transcripts of classroom A (classroom observation, focus group and teacher interview) and (re)familiarising myself with the data. I highlighted anything that seemed of particular interest and wrote down key words or phrases next to the highlighted text. Saldaña (2016) calls this *pre-coding*. After this I turned my attention to the coding framework. According to Saldaña (2016) *codes* in qualitative research typically consist of words or short phrases that capture the essence "and/or evocative attribute for a portion of language-based or visual data" (p. 4) and further, that a variety of coding methods are needed to capture complex phenomenon such as the issues surrounding the teaching of uncertainty competences. I began by employing what Saldaña (2016) calls *provisional coding*, which entails using "researcher-generated codes based on what preparatory investigation suggests might appear in the data before they are collected and analysed" (p. 297). These codes were based on the 52 elements from the audio recording grids discussed in section 3.7.2, as well as on new codes formulated during the pre-coding process. The latter were interesting new elements suggested by initial review of the data. The codes were then grouped into categories on the basis of shared characteristics. The codes distilled from the audio recording grids were organised in ten categories (the same grouping as in the grids), to which I added two additional categories, one for various codes related to the teacher and the teaching strategy, and the other for various codes related to the learner and the group. The codes that were grouped in these new categories had emerged during the coding process. An example of a code that was added to the new category Various (Teacher & teaching strategy) was: *Factors that limit a teacher from teaching about a complex, contradictory topic* (e.g. lack of knowledge, lack of confidence, lack of teaching resources). An example of a code added to the new category Various (Learner & group) was: *Children find it difficult to make choices regarding complex issues*. The Coding Analytical Framework now consisted of 12 categories and 65 codes.

Inter-rater discussions to refine coding framework

During the next step I asked my critical friend, who was familiar with the research, to code selected pages from each of the three transcripts. We compared the coding and discussed similarities and differences, which Armstrong et al. (1997) refer to as checking inter-rater reliability. This led to the rephrasing of some of the codes. It also affected my coding practice as it made me aware of the many layers of communication in the text. I decided to add footnotes to the framework for each code that required additional clarification and, as suggested by Kuckartz (2014), to employ some of the disputed excerpts as examples. This helped enhance my own thought process. Initially I thought it would also enhance the *confirmability* of the coding process, with which I refer to the degree that other researchers would confirm my coding. However, when I then asked someone familiar with the general area of educational research, but not with my study in particular, to code the same selection of pages, the coding had many more discrepancies than had been the case with my critical friend. An in-depth discussion about this revealed how important knowledge of the full context is for coding in an interpretive study. By implication it also suggests the importance of guiding readers or listeners by providing extensive description concerning the context and the definitions employed in any written or oral presentation of the study. The discussion and her fresh perspective highlighted yet more layers of communication and social interaction in my data and helped refine my framework even further. Three new codes were added (e.g. *Children display emotion when confronted with uncertainty related to contradictory information),* the framework now totalling 68 codes. No new categories emerged.

1st cycle coding methods: searching for patterns

In addition to the provisional coding method described above, I also employed four other first cycle coding methods discussed by Saldaña (2016) including: “process coding” (p. 110) which focuses on observable and conceptual action in the data, “emotion coding” (p. 124) which focuses on participant’s recalled or experienced emotions, “values coding” (p. 131) which focuses on participant’s values, attitudes and beliefs and “versus coding” (p. 136) which focuses on dichotomous language. An example of the last, of particular importance to my study, concerns the identification of *conditional language* versus *unconditional language*. Saldaña (2016) describes coding as “a cyclical act” (p. 9); by returning to the transcripts, each time with a different coding focus, new insights emerged.

Bazeley (2013) emphasizes that the process of coding can provide “a means of purposefully managing, locating, identifying, sifting, sorting, and querying data” (p. 125). While coding data the interpretive researcher searches for *patterns* which Saldaña (2016) describes as occurrences that show up more than twice in the data and are interpreted as more trustworthy indicators for human habits, salience and importance in people’s everyday lives than single occurrences would be. Hatch (2002) characterises patterns amongst other indicators according to “similarity (things happen the same way), difference (they happen in predictably different ways), frequency (they happen often or seldom), sequence (they happen in a certain order) and correspondence (they happen in relation to other activities or events), and causation (one appears to cause another)” (p. 155). I looked in particular for correspondence patterns as I was searching for a relationship between the teaching strategies teachers employed and the opportunities that were potentially created for developing uncertainty competences.

Next I focused on coding the remaining transcripts (Classroom B – E), as well as the other data sources (teaching resources and children's assignments). Meanwhile I maintained the coding framework, except where new findings demanded changes. In that case I tried to rephrase a code rather than add a new one. An example of how this worked in practice is code 50: *Children find, select and utilise information,* to which I added *Teacher teaches how to find, select and utilise information*. An observed behaviour can often be viewed from either the child's or the teacher's perspective and it makes sense to group them together. At the end of the first coding cycle the coding framework consisted of 12 categories and 72 codes (Appendix I and J).

At the beginning of the 1st coding cycle I decided to try Nvivo software to manage the coding and analysis of the data as I had collected a large amount of multimedia data sources and the literature suggested that Nvivo software was useful for linking such sources (Bazeley & Jackson, 2013). In the end I was not convinced that it was more valuable than using printed transcripts with written codes. Nvivo was useful for pulling up all potentially relevant excerpts and other coded data sources, such as teaching resources and pictures taken in the classroom. This was especially useful because the long duration of the data analysis phase sometimes made it difficult to recollect exactly what was said in each transcript. On the other hand, using printed transcripts set relevant excerpts in the context of what happened before and after the event.

3.7.4 2nd cycle coding

I then entered the 2nd coding cycle (see Table 3.7 below). According to Saldaña (2016), coding methods that fall into this category incorporate activities such as "classifying, prioritizing, integrating, synthesizing, abstracting, conceptualizing, and theory building" (p. 69). It is important to note that in my study none of the data collection methods had explanatory precedence over the other methods (Cronin, Alexander, Fielding, Moran-Ellis & Thomas, 2008). I made no attempt to transform the different kinds of collected data into one particular type. The integrity and independent epistemological contribution of the datasets was maintained (Cronin, Alexander, Fielding, Moran-Ellis & Thomas, 2008) throughout the study. The datasets were all used to create a richer picture of what transpired in the classroom.

In this phase I made use of Saldaña's (2016) 2nd cycle coding method, *focused coding*, which refers to categorising "coded data based on thematic or conceptual similarity" (p. 294). I looked for the most significant codes from the first coding cycle in order to develop salient thematic categories. Saldaña (2016) calls the process that ensued, the *process of synthesis*, which is similar to what Stake (1995) refers to as aggregation. During synthesis I combined codes whilst moving "toward consolidated meaning" (p. 10) in the form of *themes*. The five themes that emerged are the key elements of a teaching strategy focused on teaching uncertainty competences: (1) **learning objectives**, (2) **topic**, (3) **learning activities**, (4) **teaching resources**, and (5) **language and questions** (see Chapter 4). In addition, close examination of the data led to an increasing awareness of the relevance of the use of conditional and unconditional language (vocabulary and grammar) as well as the use of questions in the classroom. This reverberated with the work of Ellen Langer (See 2.4.4), leading to a further concentration on the conditional language being used in the classroom to communicate about uncertainty. I chose at this time to focus on the use of relevant vocabulary and grammar in the teacher-children interactions because such a focus had the potential to lead to concrete measures that align with the primary school curriculum and that primary school teachers could implement in their English language curriculum.

I returned to the data sources several times during this phase. For example, I recoded the transcripts with a focus on the questions the teacher and children were asking and scrutinised the unconditional and conditional language that was being used. I also explored the vocabulary employed and sometimes actively taught in each classroom that related to talking about uncertain knowledge and multiple perspectives (see Chapter 6).

Preparation data collection	**Developing 1st & 2nd version observation grids** Test observation grids during trial, which led to the decision to make audio recordings instead.			
Data collection	**Audio recordings** Classroom observations Focus group interviews Teacher interviews	**Field notes** Descriptive Analytic Methodological Reflective	**Teaching resources** PowerPoint Video Information sheets Books	**Children's assignments** Poster PowerPoint
Preliminary analysis during data collection	**Listen to recording (audio recording grids), check fieldnotes, teaching resources & assignments** whilst looking for what stood out and what surprised me			
Data preparation	**Transcriptions**			
Data analysis	**1st Coding Cycle – Interpretive Content Analysis** Coding Analytical Framework (12 categories, 72 codes)			
Thematic aggregation	**2nd Coding Cycle – Interpretive Content Analysis** Teaching strategy for developing uncertainty competences (5 themes) learning objectives, topics, learning activities, teaching resources, language and questions			

Table 3.7: 2nd Coding Cycle and emerging themes

3.8 Data verification

In this section I discuss the different data verification methods that were employed for each of the six data collection methods (classroom observation, focus group interview, teacher interview, teaching resources and children’s assignments). Considering the interpretive research design of this study it is logical to suggest, in accordance with Noble and Smith (2015), stepping away from the typical positivist constructs for attaining rigour, such as reliability, internal validity and generalisability. Qualitative researchers (Graneheim & Lundman, 2004; Lincoln & Guba, 1985; Shenton, 2004; Schwandt, Lincoln & Guba, 2007; Schwartz-Shea & Yanow, 2012) speak instead of ways in which to enhance the *trustworthiness* of their findings. Lincoln and Guba (1985) and Schwandt et al. (2007) propose alternative criteria for qualitative research; I discuss two of these criteria, credibility and transferability, which seem particularly pertinent to my study in 3.8.1 and 3.8.2 below.

3.8.1 Internal validity and credibility

Internal validity refers to the question of whether the applied indicator measures what the researcher intended to measure (Schwartz-Shea & Yanow, 2012). Internal validity assumes that there is one reality that can be correctly measured. From an interpretive perspective, however, there are multiple realities. Cohen, Manion and Morrison (2007) therefore argue that it is not merely the perspective of the researcher that establishes what reality is in terms of the study; rather it is, in addition, the meaning that the different research participants attach to the phenomenon under investigation. Guba and Lincoln (1985) suggest that referring to *credibility* rather than internal validity would better reflect the interpretive perspective. There are many strategies that can be employed to enhance the credibility of an interpretive research project.

In addition to a thorough preparation, the formulation of clear research questions congruent with the research design, philosophical justification, detailed descriptions of how the data was collected and analysed (Miles & Huberman, 1994; Patton, 1999; Stake, 1995), I applied seven data verification strategies to enhance the credibility of this interpretive research project.

The first strategy is what Thurmond (2001) calls "methodological triangulation" (p. 254) which, in my study, involved the use of six different data collection methods (see Section 3.6). Bazeley (2013) explains that the aim is to compare the inferences drawn from the various data sources. However, I agree with critical researchers such as Schwartz-Shea and Yanow (2012) and Hammersley (2008) who point out that triangulation remains a term rooted in positivist approaches. Contrary to positivist research where the aim is to find convergence across the multiple sources and, in doing so, find the *truth*, interpretivist research rests on the basic assumption that there are multiple ways of meaning-making and multiple meanings. I was also alert to the caution that triangulation can be ambiguous as my six data sources (audio recordings from classroom observation, focus group interviews and teacher interviews, as well as teaching resources and children's assignments) come in forms that defy direct comparison (Barbour, 2001). As a result of these disparities, it is difficult even to say what would constitute a congruent picture. On the other hand, because each data source reflects what was happening from a different angle, they can lead to a more complete description of the phenomenon.

The second data verification method, "familiarity with the culture of participating organisations" (p. 65), relates to the preparation I did before each classroom observation. After talking briefly with the teachers when I first met them, I had a more elaborate telephone conversation with each to discuss how the observed lesson would fit into their programme and the school's curriculum. I also studied the school websites and school handbooks to get a better impression of each school community before my first visit. Upon arrival at the school I was often struck by the displays in the corridors of what the children had produced during different school activities. For example, school B exhibited many projects focused on sustainability challenges. This influenced my expectations concerning the observed lessons and the interviews, for example, as to the level of engagement I expected with respect to a sustainability topic. The Classroom B children were indeed very engaged in the project about dams and concerned about the potential consequences for people and environment.

As my third verification strategy, I employed "member checking" (p. 408), which Bazeley (2013) defines as checking with the research participants to see if they agree with the findings. It is widely promoted by scholars for the enhancement of the credibility of the research findings (Lincoln & Guba, 1985; Krefting, 1991; Stake, 1995; Creswell & Miller, 2000; Shenton, 2004; Cohen, Manion & Morrison, 2007; Schwartz-Shea & Yanow, 2012; Bazeley, 2013). This took place in various phases of my research. Directly after the end of the observed lesson I discussed key events with the teacher and in doing so I checked my own interpretation of what happened in the classroom. This was particularly relevant for the recordings from the lessons as well as the field notes that I made during the observations. During the data analysis I provided each of the five teachers with a 1-page summary of my interpretation of the teaching strategy the teacher had employed in the observed lesson and the opportunities it provided for the development of uncertainty competences. See Chapter 9 for a description of the teaching strategy per classroom. I asked the teachers to respond by email if they felt that anything needed to be changed, added or removed. No changes were proposed.

The fourth verification method I employed are what Shenton (2004) calls "debriefing sessions" (p. 67) and refers to the meetings with my supervisors and with my critical friend to discuss everything from the development of the research questions to my literature search, the research design, implementation issues, analysis and the presentation of the findings. These sessions helped me uncover tensions in the research process that I could then try to resolve, as well as helping me reflect on my assumptions. It was for example very useful to reflect on the classroom observation with my critical friend in preparation for the focus group interview, and similarly to reflect on the focus group interview in preparing for the interview with the teacher. During the focus group interview with children from Classroom D some of the children mentioned going home and double checking the teacher's information about there being no beavers in the wild in Scotland. This prompted me to ask the teacher if he thought the children ever doubted the information he provided them with. The teacher then described the tension between discussing facts and opinions, contradictory views, knowledge sources and the children's expectation that the teacher always tells the truth.

Verification strategy number five involves, in Shenton's (2004) words, "peer scrutiny of the research project" (p. 67), and includes opportunities to publish peer reviewed articles, or in my case, a book chapter that resulted from my initial literature research, as well as presenting my research to and receiving feedback from education scholars. Presentations that offered such opportunities included: PhD Seminar Udeskole and Outdoor Education (Denmark, April 2015), Interweaving Conference Moray House School of Education (Scotland, September 2015), a 3-day Seminar Outdoor and Environmental Education Research (Scotland, April 2016), 3rd European Conference on Curriculum Studies (Scotland, June 2017), 9th World Environmental Education Congress (Canada, September 2017) and Beneluxconferentie: Leren leven binnen de grenzen van onze aarde (Netherlands, November 2017). I also presented and defended my work in front of a first-year Progression Board Committee (September 2015) and I presented several times in the University of Edinburgh Outdoor and Environmental Education Group during the period 2014 - 2017. These exchanges provided me with opportunities to critically assess and refine my ideas as well as the interpretation of my empirical data. One memorable discussion focused on concerns around encouraging children to challenge knowledge sources. A conference participant suggested that a topic such as climate change should be "off limits" with respect to challenging knowledge sources because it could lead to climate change denial, which was unacceptable and dangerous. I argued that avoiding contentious topics is doing a disservice to our children who are surrounded by contradictory information and disinformation regarding many potentially devastating issues. The interchange reinforced my thinking regarding the importance of uncertainty competences. In answer to this conference participant's concern, welcoming uncertainty into the learning environment paired with developing uncertainty competences at an early age could provide the children with tools with which to face the issues she wished to protect them from.

The sixth data verification method that I used was keeping what Morrow (2005) calls a "self-reflective journal" (p. 254) throughout the research process; this method is encouraged by many scholars (Miles & Huberman, 1994; Shenton, 2004; Schwartz-Shea & Yanow, 2012). In the journal I noted pivotal decisions, impressions from the classroom observations and interviews, thoughts on emerging patterns in the data and notes from discussions with teachers and researchers about my study. This was an extremely valuable aid to memory.

The seventh and final verification method consists of sharing background information about myself with the reader. Shenton (2004) and Patton (1999) emphasise the importance of this practice because they consider the qualitative researcher to be a research instrument. As Yanow (2006) puts it, the interpretive researcher cannot stand objectively outside the subject under investigation. Relevant information might include my experience and training and my personal interest in the subject under investigation (see Preface and Section 3.2.4). For example, I did not have a teaching degree and was not Scottish. I brought that background with me to the classroom observations (e.g. how I introduced myself to the children) and the interviews (e.g. asking questions about teaching in Scottish primary schools that I might not have asked if I had had a background as a primary school teacher or had grown up in Scotland). As the observations and the interviews all involve interpretive acts, Schwartz-Shea and Yanow (2012) point out that this kind of information may be relevant for the reader's understanding of the outcomes of the study. In summary, I employed seven data verification strategies in order to ensure a rigorous and extensive data analysis process.

3.8.2 Generalisability and transferability

Generalisability, or *external validity*, deals with questions concerning whether or not the research conclusions can be generalised outside of the specific research situation (Cohen, Manion & Morrison, 2007). Researchers agree that the production of contextualised, local knowledge is inherent to interpretive research (Miles & Huberman, 1994; Cohen, Manion & Morrison, 2007; Schwartz-Shea & Yanow, 2012; Bazeley, 2013). Meaning-making takes place in a particular situation, place and time. In this light it is not relevant to talk about interpretive research findings that can be generalized and broadly applied. This does not mean, as Bazeley (2013) makes clear, that the findings are not relevant for other cases. To enhance the transferability of a study, many researchers (Lincoln & Guba, 1985; Creswell & Miller, 2000; Shenton, 2004, Cohen, Manion & Morrison, 2007; Schwandt et al., 2007) postulate the importance of *thick descriptions* which refer to detailed narratives about the phenomenon under investigation and the context in which the fieldwork took place. Detailed descriptions of my classroom observations have been provided (see Appendix C) and many excerpts from the data have been included in the findings chapters (see Chapters 4-8) to give the reader a real sense of the classroom observations and interviews (Hatch, 2002). These narratives enable readers to assess the relevance of the findings to other cases for themselves.

3.9 Summary

In Chapter 3 I provided a detailed and transparent audit trail (Cohen, Manion & Morrison, 2007; Schwandt et al., 2007; Noble & Smith, 2015), in order to allow the reader to follow the entire sequence of my research. Central to my study is an interpretive research paradigm that informed all aspects of the methodology. I selected a multiple case study design involving five Scottish primary 6/7 classrooms, collected six different data sources (classroom observations, field notes, focus group interviews with children, interviews with the teachers, teaching resources and children's assignments), and employed interpretive content analysis to interrogate the data. Although only five classrooms were studied, the in-depth analysis led to interesting contextualised findings that served to refine my ideas about teaching uncertainty competences in the upper primary years. In Chapter 4-9 attention moves to the findings. The Guided Walk through the findings chapters that precedes Chapter 4 explains what the reader can expect from these chapters.

A Guided Walk through the findings chapters

This study aspires to discover which characteristics of the learning environment of an upper primary classroom facilitate the development of uncertainty competences. In Chapter 2 I have specifically discussed the key elements of the learning environment: the physical (or virtual) setting, the learner, the group of co-learners, the teacher, the cultural institutions, the classroom procedures, and the teaching strategy. The findings from my study placed alongside the literature shed light on one of those elements in particular: the teaching strategy. Findings from the classroom observations, the audio recordings and the employed teaching resources in the five P6/P7 classrooms are reflected upon and enriched by the focus group interviews and teacher interviews. In a few classrooms the children made posters and PowerPoint presentations providing additional insights. Colourful narratives based on interwoven themes that emerged from the data will be encountered as the reader moves through the upcoming findings chapters. The themes relate to the teaching strategies the different teachers employed to teach about complex and contradictory sustainability topics, and the opportunities for the development of uncertainty competences these strategies afforded.

The themes that emerged from the data together form the components of a teaching strategy. They are the: (1) learning objectives, (2) topic, (3) learning activities, (4) teaching resources, and (5) language and questions used by the teacher. The teacher makes choices regarding each of these components when designing lessons, which in turn influence the presence or absence of uncertainty, complexity and contradiction in the classroom. Upon close examination of the findings alongside the relevant literature one of those themes, the teacher's language and questions, fortuitously generated many interesting ideas. I therefore focused on deepening the analysis of that theme. The reader will find that the first four themes in findings Chapter 4, although all relevant and interconnected, are less deeply worked-out than the language theme discussed in Chapters 5 to 8. I made that decision because the aspect of language use in the dialogue about teaching children how to deal with uncertainty is underexplored and at the same time has the potential to offer concrete measures teachers can consider employing in their day-to-day teaching practice. In addition, these findings suggest a path towards beginning to teach children (in the upper primary school years) uncertainty competences.

This current study continues to build on earlier published work concerned with teaching uncertainty competences. In Chapter 2 I presented a 17-item list of uncertainty competences (Tauritz, 2016). During the data analysis three new uncertainty competences emerged. They are included in the Revised List of Uncertainty Competences which will be presented in Chapter 10 (see Table 10.1). Where they are discussed in the findings chapters they will be denoted by a star:

Being able to conduct research on complex and uncertain topics★
Being able to interpret what others are communicating about their degree of certainty★
Being able to express one's own degree of certainty★

I invite the reader to follow the *Trail of the Teacher* as each of them moves through their own classroom, sometimes interacting with the whole class, sometimes with a small group of children, and at other times with an individual child. A brief description of each of the classrooms and the observed lesson can be found in Section 3.4.3. For a more detailed account of the case studies see Appendix C. In the findings chapters I will refer to Classrooms A to E. Table 4.0 below provides a quick overview of the lesson topics taught in each of those classrooms.

Classroom	**Topic of the observed lesson**
A	Global warming
B	Dams
C	Dying of the sun and birds
D	Beaver reintroduction
E	Pollination

Table 4.0: Lesson topics selected by the five observed teachers

Due to the nature of the observations and the use of audio recordings in classrooms in which up to 25 children were sometimes simultaneously in active discussion with each other, it was not always possible to provide a child's name and gender during teacher-child interactions. Those occasions are indicated by the word *child* in an excerpt. In some cases I was able to tell whether the child was a boy or girl. However, as there was no evidence of gender being relevant in this study, I decided to use the gender-neutral identifier *child*. Where I could specifically identify the child's identity I used pseudonyms as the knowledge of who the child was could, for example, reveal that particular children changed over time in their approach to questioning the certainty of information. In such instances it was, in addition, often possible to deepen the analysis with information gained from the focus group and teacher interviews. The texts in italics that are dispersed throughout the findings chapters are the children's and teacher's own words. They were extracted from the transcripts of the classroom observations, the focus group interviews and the teacher interviews. These words represent the individual teachers, the individual children that could be identified, and in the other cases the *children's voice*. Where teachers used teaching resources made by third parties, such as videos and PowerPoint presentations, I interpreted the language used in them as if they were the teacher's own words.

In the coming chapters many examples drawn from the five classrooms will be discussed. Each classroom offers the reader valuable lessons. Examining them critically should not be seen as a critique of an individual teacher's performance, but rather, as Alexander (2006) posits, as offering chances to make dilemmas faced during a particular observed lesson, and at times experienced by all teachers, explicit and discussable. Only in doing this, can we further our joint understanding of how to facilitate the development of uncertainty competences.

Chapter 4 Teaching strategy: A teacher's choices

> Perhaps we need a different vision of education, a vision that foregrounds educating for the unknown as much as for the known. Perhaps we need a vision of education that's more "future wise," reflecting our best guesses about what's most likely to happen and foregrounding flexible knowledge likely to inform whatever does happen.
>
> (Perkins, 2014, p. 20-21)

4.1 Introduction

As discussed in *A Guided Walk through the findings chapters*, Chapter 4 will focus on the first four components of the teaching strategy, namely learning objectives, topics, learning activities, and teaching resources, and Chapters 5 to 8 will discuss the fifth component, language and questions used by the teacher. These five themes will be discussed and related to the development of uncertainty competences and the presence or absence of uncertainty, complexity and contradiction in the classroom. In Section 2.5 I briefly mentioned that one of the key elements of a learning environment consists of the teaching strategy. In Section 4.2 I present a more detailed definition of a teaching strategy. I will discuss the key elements of the teaching strategy as they emerged in my study in the subsequent sections. In Section 4.3 I focus on the learning objectives, which form the basis of the strategy the teacher selects. In Section 4.4 I discuss what the teachers in my study thought in regard to teaching about complex issues to children in P6/P7. In addition, I argue that the field of learning for sustainability affords valuable topics for the development of uncertainty competences. Section 4.5 provides an overview of the learning activities that were used in the observed lessons and I reflect on the possibilites they offered for facilitating the development of uncertainty competences. In Section 4.6 I reflect briefly on the employed teaching resources. As the language and questions used by the teacher became the focal point of my study, they will be discussed in more depth in the subsequent chapters.

4.2 Teaching strategy

Ever since I set out to study how teachers can prepare their students for a complex and uncertain world, I have been searching for effective teaching strategies. In Chapter 2, I shared my definition of a learning environment and I explained that the teaching strategy was a key element. The literature tells us that teaching strategies refer to, for example, the methods, procedures, techniques and processes that shape the instructions with which teachers facilitate student learning (Orlich et al. 2013; Wandberg & Rohwer, 2010). According to Toohey (1999) "A teaching strategy is … a plan for someone else's learning, and it encompasses the presentations which the teacher might make, the exercises and activities designed for the students, materials which will be supplied or suggested for students to work with, and ways in which evidence of their growing understanding and capability will be collected" (p. 152). Initially I found this definition useful, because it makes concrete for a teacher what needs to be considered when developing a lesson. However, it was not until I started examining the data that an even clearer perspective on what I now regard as the five key components of the teaching strategy emerged. Based on my findings, I define a **teaching strategy** as the lesson plan the teacher designs with particular **learning objectives** for the students in mind, to be achieved by using carefully chosen **topics**, well designed **learning activities**, either purposely developed or selected **teaching resources**, and the deliberate use of **language and questions** to support the teaching process (see Figure 4.1 below). The reader will note that in contrast to Orlich et al. (2013), Wandberg and Rohwer (2010) and Toohey (1999), topic selection, and the language and questions teachers intend to employ are also included in my definition. In the rest of the section each component is considered in the context of teaching uncertainty competences.

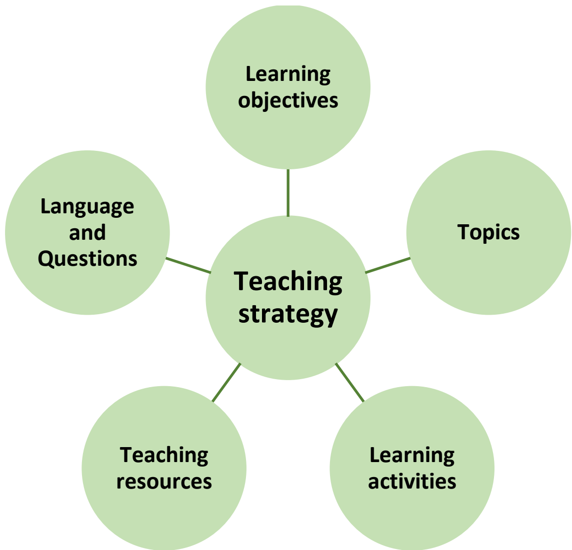

Figure 4.1: The five key elements of the teaching strategy

4.3 Learning objectives

According to the Dictionary of Education (Wallace, 2015), a learning objective is:

> A clear statement of what the student or pupil should have learned by the end of the task, the lesson, the scheme of work, or the course of study. Learning objectives provide focus and direction and clarify what must be assessed in order to ascertain whether learning has taken place. … On the basis of these the teacher will construct a scheme of work, which is then broken down into individual lessons plans, which between them, provide coverage of all the learning objectives … (see 'objectives, learning', para 1).

I asked the teachers in my study to design between one and three lessons about a sustainability topic of their choice. It needed to be a complex topic and contain contradictory information. As I did not want to unduly influence the teacher's choices, I did not explicitly tell the teachers that my focus was on teaching learning objectives relevant to the list of uncertainty competences I had established before I started doing the fieldwork (see Section 2.3.3). I employed my initial list during the data collection and first analysis phases. The list has since been expanded to include three additional uncertainty competences that emerged from my findings, as will be addressed in the subsequent findings chapters. When discussing uncertainty competences in Chapters 4 to 9 I will refer forward to the Revised List of Uncertainty Competences provided in Chapter 10.

4.3.1 Learning objectives selected by the five classroom teachers

I asked the teachers to provide me with a lesson plan before the observed lesson(s). The teachers from Classroom C and D gave me full lesson plans that specified outcomes and experiences articulated in Curriculum for Excellence (Scottish Executive, 2004), the lesson objectives, success criteria, activities, and in the case of Classroom C the evidence that teacher intended to use to check if the success criteria had been met. Classroom Teachers A, B and E did not specifically mention outcomes and experiences from Curriculum for Excellence (Scottish Executive, 2004) in their lesson plans, or during the interview. The Classroom B teacher sent me an email before the lesson that contained three lesson objectives. The teachers from Classroom A and E did not provide me with any kind of lesson plan or learning objectives. During the interviews I asked the teachers about the learning objectives they had set for their lesson. I established that the teachers from Classroom A and E essentially saw the transfer of content knowledge, respectively about global warming and about the process of pollination and plant reproduction, as their learning objectives. Although global warming certainly is a complex and uncertain topic, understanding and responding to the contradictory information was not an explicitly mentioned learning objective. The lesson about plant reproduction included complex vocabulary, but, as it is not a particularly uncertain or controversial topic, it is unsurprising that no learning objectives related to uncertainty competences were indicated.

The Classroom B teacher specified both content-related learning objectives *to develop knowledge and understanding of what a dam is* and *explore the advantages and disadvantages of dams*, as well as a skill-related learning objective *to debate the advantages and disadvantages of dams with regard to their effects on our* environment as her learning objectives. As the teacher and the children explored the advantages and disadvantages, they were examining different perspectives. This relates to the development of the uncertainty competences being able to understand people with different perspectives and being able to reason. The children were also developing the language needed to talk about multiple perspectives. This was not a predetermined learning objective, but certainly relates to the exploration of the pros and cons of dams and could have easily been emphasised as a learning objective and expanded on in the classroom (see Section 4.3.2).

The teachers from Classroom C and D worked out their learning objectives in much more detail. They each articulated three outcomes and experiences selected from the Curriculum for Excellence (Scottish Executive, 2004). One of those outcomes and experiences was mentioned in both lesson plans: SCN 2-20b – “I can report and comment on current scientific news items to develop my knowledge and understanding of topical science” (Scottish Executive, 2004, p. 277). The formulated learning objectives related to these outcomes and experiences and appeared to coincide with what was actually being taught during the observed lessons.

Teacher C developed a lesson comprising of three observed sessions. She mentioned two assessment questions for the first lesson: *Are wind farms a good or a bad thing?*

and *Are there other solutions which may be better than putting more wind farms in the Lammermuir Hills?* The school is located near these hills, connecting the topic to the children's experience. Her learning objective for lesson one was *I can identify a complex scientific issue* [wind farms] *and am able to discuss the main ideas* and her success criteria were *being able to participate in the group discussions with your own thoughts and feelings* and *listen to the views of others*. The main topics for the second lesson differed from the original lesson plan because the teacher adapted it on the basis of the interests the children displayed during the first lesson. The new assessment questions were *What do birds do for the world?* And *How will the Sun die?* For lesson two the learning objective was *I can research and discuss a complex issue* [role of birds and dying of the Sun], *giving my own ideas and opinions* and her success criteria were *being able to participate in the group discussions with your own thoughts and feelings* and *listen to the views of others*. Lesson three's learning objective and success criteria were the same as lesson two, with an additional learning objective *I can back up my ideas and opinions with evidence from scientists and researchers* and the additional success criterion *being able to justify the information put in a presentation and explain it*. The evidence with which to check if the success criteria had been met centred on being able to *present information* verbally as well as *with PowerPoint presentations*, being able to *justify their … statements*, *express a view or opinion*, and *present evidence*. The learning objectives relate to several uncertainty competences, namely: being able to understand people with different perspectives, being able to find, evaluate and utilise information, being able to reason, and being able to respond with the underlying probabilities (Tauritz, 2016). The learning objectives are also related to the development of language skills necessary to understand other people's degree of knowledge uncertainty as well as express their own (see Section 6.2.2). However, because what these language skills might be is never established, it is left to chance which words and grammatical structures will be employed in the teacher's and children's communications. Having said that, there were clear examples during the lessons of this teacher discussing certain expressions and words with the children (see Section 6.2.3). During the interview the teacher from Classroom C mentioned another learning objective which was not articulated as such in the lesson plan: *to question things and to ask questions of themselves, ask questions of others*. This directly relates to the uncertainty competence being able to entertain an enquiring mind (Tauritz, 2016). The children in this classroom certainly asked more questions than children in other classrooms see Section 5.2.2.

The teacher from Classroom D related his learning objectives to outcomes and experiences from three curriculum areas Literacy and English, Sciences, and Social studies articulated in Curriculum for Excellence (Scottish Executive, 2004). Interestingly the science outcome mentions *develop knowledge and understanding of topical science*, even though the teacher did not further formulate learning objectives focused on content knowledge in the lesson plan. During the observations and the interview, however, it became evident that transferring content knowledge about the *flora and fauna of Scotland* and in particular about *beavers and ecology* were important learning objectives to him as well. The learning objectives that he did formulate in his lesson plan were more focused on skills than on content knowledge, though the Curriculum for Excellence advocates both (see Section 1.3.1). The first learning objective in his plan was *learning to use information to understand a controversial topic* and the success criterion entailed using *sources to find information to back up a point of view*. The second learning objective and success criterion are best summarised by quoting the Literacy and English LIT 2-29a outcome that he noted in his lesson plan: “I can persuade, argue, explore issues or express an opinion using relevant supporting detail and/or evidence” (Scottish Executive, 2004, p. 16). The uncertainty competences that are being addressed are similar to those addressed in Classroom C: being able to understand people with different perspectives, being able to find, evaluate and utilise information, being able to reason, and being able to respond in accordance with the underlying probabilities (Tauritz, 2016). At the same time, the Literacy and English outcome that this teacher indicated could have provided a useful point of departure for addressing other uncertainty competences related to the development of language that can be used to communicate about the notion of certainty of knowledge (see Section 6.2.2).

4.3.2 Articulating uncertainty competences as learning objectives

It is noteworthy that in this study the same narrow selection of uncertainty competences, often focused on *reducing uncertainty*, is more likely to be mentioned in lesson plans about complex sustainability topics in P6/P7 than other uncertainty competences from the list. Examples include the ability to understand people with different perspectives, the ability to find, evaluate and utilise information, the ability to judge the credibility and cognitive authority of information sources, and the ability to reason. These uncertainty competences are typically already a part of the Curriculum for Excellence. They generally fall into the broad category of critical thinking, competences which are mentioned in all major frameworks for 21st century skills (Voogt & Pareja Roblin, 2012) (see Section 1.2.2).

However, there are also uncertainty competences teachers are not at all, or at least less aware of such as: being able to use uncertainty as a catalyst for creative action, being able to employ lateral thinking and being able to prioritise among many urgent issues (Tauritz, 2016). Although Teacher A's learning activity, involving ordering environmental issues the children had listed in the previous learning activity from most to least important, supported the development of the latter competence, she was not aware of this and therefore missed the opportunity to expand on this with the children (see Section 4.5).

4.4 Topic selection

Topic selection is an important part of formulating the teaching strategy, as topics afford very different learning opportunities. If the goal is to teach uncertainty competences, then a learning environment in which uncertainty is made explicit and communicating about uncertainty is encouraged, is required (Tauritz, 2016). In the words of Beghetto (2017) "If we want to prepare students to respond productively to uncertainty, we need to have them tackle a full range of challenges, including those addressing ill-defined problems and big issues" (p. 23). Suitable topics can be characterised in terms of compositions of varying degrees of uncertainty, multiple and incompatible perspectives and values, contradictory information, and decision-making regarding problems without obvious solutions. The teachers in this study were asked to select any complex sustainability topic including a confrontation with contradictory information that they would like to teach about. The topics they chose were: global warming (Classroom A), building dams (Classroom B), wind energy / dying of the sun / role of birds (Classroom C), reintroduction of beavers (Classroom D) and pollination

(Classroom E) (see Section 3.3.2). Section 4.4.1 focuses on the teacher's interpretations of what constitutes a complex topic. Section 4.4.2 describes how the teachers in this study felt about teaching complex environmental topics to children in P6/P7. Subsequently, Section 4.4.3 explores the characteristics of topics that afford opportunities for the development of uncertainty competences. In addition, I argue the merits of sustainability topics as a rich source for teaching children how to handle knowledge uncertainty.

4.4.1 Teachers' interpretation of a complex topic

The teachers' topic selections were based on quite different interpretations of what constitutes a *complex* topic. Teacher A chose a topic that can be characterised by complicated content knowledge. Climate models encompass many variables that influence each other in intricate ways and are certainly not without ambiguity. Teacher B taught about the topic of building dams and viewed the multitude of advantages and disadvantages of building dams and how they affected different people and the environment, as complex. Paul (1995) refers to such topics as "multilogical (multi-dimensional) problems: Problems that can be analysed and approached from more than one, often from conflicting, points of view or frames of reference" (p. 544). Monological issues on the other hand are viewed from one point of view, for example: How much CO_2 can a Douglas fir absorb in one year? In agreement with Paul (1995) I propose that it could be beneficial to distinguish between monological and multilogical problems; selecting the latter provides more material for teaching uncertainty competences. Multilogical is often rendered as inter-disciplinary. Section 4.4.3 demonstrates how a seemingly monological topic can often easily be transformed into a multilogical topic. The teacher from Classroom C interpreted complex issues as issues that involve other people's points of view and differing opinions. She felt strongly that children need to *be able to listen to other people and accept that other people might think differently to you and that it is okay*. Her interpretation provided particularly rich opportunities for teaching uncertainty competences in the category of tolerating uncertainty. Teacher D's perception of a complex issue was a lesson in which the children were offered larger amounts of content knowledge in other words less *chunked into little bits* than in earlier school years. In Classroom E the teacher had originally communicated that she would teach about the complex topic of dying bee colonies around the world and the contradictory perspectives regarding the causes. However, when she looked into it she discovered as she said: *the research is still a bit uncertain and I was a bit worried about going and speaking to them about things that I wasn't 100% comfortable with*. She decided to avoid a complex topic characterised by uncertain knowledge and multiple perspectives. Instead she decided to select a topic she also considered complex for the children because it contained unfamiliar vocabulary and they had limited understanding of the biological processes concerning pollination and plant reproduction.

In conclusion, teachers have different interpretations of what constitutes a complex topic, ranging from topics that include lots of unfamiliar vocabulary, complicated content knowledge, confrontation with multiple perspectives and values, and larger quantities of information presented to the children at the same time.

4.4.2 Teachers' perspectives on teaching complex and uncertain topics in P6/P7

When asked, both researchers and educators have expressed their opinions to me about teaching primary school aged children about complex, uncertain and contradictory environmental topics. At the same time, it is difficult to find research that takes an in-depth developmental perspective on many of the uncertainty competences needed to engage with these topics. There are authors such as Estyn (2014) and Taylor, Quinn and Eames (2013) who describe children as being able to handle complex sustainability topics in primary school. According to Spiteri (2015), even children as young as three to seven years are able to discuss sustainability issues on a basic level. The psycholinguistic literature, however, offers more detailed information about the development of an understanding of relative uncertainty, as well as about children's development of the language necessary to communicate with others about the certainty of knowledge. The teacher's use of language in the classroom will be explored in-depth in Chapters 5 to 8. A developmental perspective on communicating about the certainty of knowledge and multiple perspectives is offered in Section 10.5. The rest of this section will focus on the ideas of the teachers from this study concerning teaching complex issues in P6/P7, involving children age 10-12.

When the teacher from Classroom A was asked about her thoughts on teaching complex environmental issues in her P7 classroom she shared the following concern: *We are still getting to grips with the curriculum and how to teach these sorts of complex issues … you have to start at primary 1, primary 2 … to get the level that I think they could discuss at primary 7 ... There has to be a progression. I can't start in primary 7 and start talking about global warming if there has nothing been going on before*. This teacher was of the opinion that the children could potentially deal with these topics, but that it requires applying "lines of development" (Scottish Executive, 2004, p. 3) which describe the progression in learning during the children's primary education.

Teacher C had a very pronounced response to the question if children in P6/P7 are ready for learning about complex sustainability issues:

Teacher *I think all age groups can cope with a complex issue. It just depends on the issue. Five-year olds can cope with complex things, but it has just got to be done in a slightly different way and the content would have to be appropriate to that age group. But I don't think you should be put off looking at complex issues until a certain age. Because often, the younger ones are more open to other people's ideas and will be more open to listen to other people's point of view whereas the older you get the more of a fixed mind-set and a closed ... If you don't start early enough and be able to listen to other people and accept that other people might think differently to you and that is ok, then it is not going to be so easy to do, the more complex issues when they get to age eleven or twelve. So I think it is really important not to be put off talking about complex issues with the smaller children … But I think maybe about the age of nine, ten, if you haven't exposed them to listening to others and coping with change and coping with difference and complex issues and differing opinions then at that point they would probably be more difficult to bring back to it…*

The teacher from Classroom D was of the opinion that the children in P6 *can kind of grapple with more bits of information … Further down everything needs to be quite clearly broken up and chunked into little bits. I think further up they can maybe cope* *with slightly more things at the same time and kind of start to get that balance*. He had not yet taught a P7 class and was therefore not sure of their abilities. When specifically asked how the children handled the contradictory perspectives about beaver reintroduction he shared with me that it very much depended on the individual child. Some are *quite mature* [Levy] *has a quite developed kind of grasp on things. I think he can kind of always handle both sides of the argument and see that there are strong cases on both sides. I think some of them can handle it more than others.* He said that the children in P6 were beginning to develop that skill. However, he also added *I think others may be just still looking for a right and wrong answer*.

Although the teacher from Classroom E did not teach an uncertain topic containing contradictory information, I did ask how she thought the children would handle a project that had contradictory perspectives to consider. She was far less optimistic about this than, for example, Teacher C. Teacher E shared the following thoughts:

Teacher *There would be some of them, especially the ones that are more higher achieving, they would probably question it a lot more … And there is some of them, as well, that are 'ok if this is the information I will just agree with it' and they won't question it … I think sometimes we are giving them too much information ... I try to make it simpler, I don't give them too much. Maybe give them a couple of bits of information from both perspectives ... I know you are looking at complex, but some of them just can't cope yet. And I don't know whether some of them ever will be able to cope when it is more complex.*

When asked whether a complex environmental topic such as climate change should be discussed with this age group she answered:

Teacher S*o long as we are not having it as doom and gloom ... We need to maybe say, well some of it maybe we can change, we could maybe do things differently and it might help it, but there are other things we have just got to accept are going to happen, because as human beings we have got no effect whatsoever on it … So long as we try to keep it on simpler terms for them … age and stage appropriate. I think they need to know. They are* *part of this world now and they are going to be the people that might be making the decisions in the future, so if we start giving them the information, they hopefully will be able to build on it as they grow and mature.*

Teacher E's perspective regarding an optimistic framing of environmental issues and offering children positive scenarios concurs with authors such as Kelsey and Armstrong (2012), Noble (2013), Sobel (1996) and Taylor, Quinn and Eames (2013). They warn that although these complex environmental topics can and should be taught in primary school, teachers should avoid a narrative of gloom and doom and instead provide a context in which children can explore their feelings, forge a strong positive connection to nature, and develop resilience and creativity. Ojala (2012) suggests that constructive hope could work as a motivational force for pro-environmental behaviour, as long as one guards against denial.

In summary, teachers in this study displayed a range of perspectives on the ability of children in P6/P7 to handle complex topics. Generally, the high achieving children are expected to be able to handle complex and uncertain topics in P6/P7. Some teachers in my study suggested that children need to be prepared for complex topics in P6/P7 through the introduction of complex and age-appropriate topics earlier in their school career. More research is needed regarding the age and stage appropriateness of teaching these complex and uncertain environmental issues.

4.4.3 Characteristics of complex and uncertain topics with a large learning potential

Selecting appropriate topics for the development of uncertainty competences is not unproblematic. Teachers need a good understanding of the competences they set out to develop, as well as of the topic characteristics that afford more or fewer learning opportunities to develop them. It was discussed in Section 4.4.1 and Section 4.4.2 that the teachers in this study had different interpretations of what a complex sustainability issue entailed, which learning objectives could be achieved by teaching about them, and how much complexity and contradiction the children could handle. In Section 4.4.3 I will examine the characteristics that could contribute to a topic's potential for developing uncertainty competences. Table 4.1 provides an overview of the topic characteristics which derive from the way the teacher presented the topic to the children.

Classroom → **Topic →** **Characteristics ↓**	A Global	B Dams	C Wind turbines	C Dying of the sun	C Role of birds	D Reintroduction of beavers	E Pollination
Complex	X	X	X	X		X	X
Uncertain	X		X	X		X	
Multilogical	X	X	X	X	X	X	
Controversial	X	X	X		X	X	
Dynamic	X		X			X	
Emergent				X	X		
Misinformation	X		X				
Confusing	X	X	X	X		X	
Immediate/urgent	X	X					
Personally relevant						X	
Unknowable	X			X			

Table 4.1: Overview of the topics and how the teacher framed them

Whether a particular topic can be characterised as, for example, immediate or personally relevant for a child is largely dependent on the context. For a child growing up on one of the Pacific islands at risk of disappearing due to climate change, a topic such as climate change is far more urgent and personally relevant than it would be for a child growing up in Scotland. I suggest, as did Spiteri (2018), that topics can be made more personally relevant by connecting them, for example, to local issues in the children’s world. The overview in Table 4.1 is based on the approach the teachers took in this study. For instance, the topic of pollination was approached purely from a biological perspective. However, it could easily have been transformed into a complex, inter-disciplinary and controversial sustainability topic by talking about the causes of the dying bee colonies around the world and the effect this may have on our long-term food production.

Teacher A selected global warming and the changing weather patterns as her main topic for the lesson. It is a useful topic for this discussion as it incorporates many topic characteristics relevant to the development of uncertainty competences (see Table 4.1). Global warming is a challenging topic in many respects and therefore it is not surprising that the teacher shared with me during the interview, that although she was interested in the environment, she did not feel confident teaching about such a controversial topic.

Teacher *… I am interested in the environment and I would love to do that, but actually I don't know quite how to deal with all the … like talking about global warming as a topic area… and discussing … I don't even know whether there is enough information to run a topic about it … I have just not done that kind of thing where we have taken sort of controversial issues … So therefore, I don't feel knowledgeable about them*.

Global warming and changing climate patterns are indeed very complex issues. The topic is also *inter-disciplinary,* or *multilogical,* as Paul (1995) refers to it, and cannot be fully understood without looking at the broad spectrum of climatological, biological, geological, economic, cultural, political and social processes involved. Many scholars suggest that learning how to deal with sustainability challenges requires an inter-disciplinary and holistic teaching process (Morrison, 2008; Hall, 2014). Inter-disciplinary education implies connecting different subjects; integrating knowledge is a requirement for handling complex and therefore inherently uncertain issues. A holistic teaching process focuses on a topic in its totality. It encourages incorporating multiple knowledge sources. Although according to Taylor, Quinn and Eames (2013), it is hard for teachers and primary school children to gain a precise and sophisticated understanding of holistic inter-disciplinary scientific phenomena such as climate change, it is nonetheless essential.

In addition, although there is an increasingly robust body of knowledge, for example, published by the IPCC (Intergovernmental Panel on Climate Change), there are also many knowledge uncertainties. Navigating the scientific language of probabilities is no small feat and requires specialised skills. Another characteristic mentioned by

Voogt and Pareja Roblin (2012) is the *dynamic* and continuously changing nature of this topic. The findings suggest that teachers are aware of the need to keep up to date regarding new ideas and knowledge as they enter the public realm and adjust their teaching accordingly.

Higgins (2009) highlights another characteristic, stating that "many modern issues also are difficult to fully understand because they are obscured, hidden, or even subject to forms of misinformation" (p. 50). The issue of misinformation is also troubling with respect to a *controversial* and *urgent* topic like global warming. Groups, such as the Heartland Institute, who deny the scientific consensus regarding the anthropogenic factor in global warming, actively disseminate educational materials (Banerjee & Lee, 2017) and try to influence school boards and state and national governments to pursue their anti-climate agenda (Branch et al., 2016). There are many educators, in contrast, who, based on scientific consensus, promote another narrative regarding the critical role of anthropogenic emissions in the process of global warming and want this to take a prominent place in education. These contradictory perspectives can make it even more confusing for teachers to know which knowledge authority to trust and what the evidence tells them to teach. I asked the Classroom A teacher how she viewed teaching about such a confusing topic.

Researcher	*Do you see value of discussing, and really confronting the children with this confusion and not really knowing what the best way forward is? Do you see it as useful to confront them with that now, while they need to be able to make these kinds of decisions later in life when they are adults?*
Teacher	*I would definitely say there was value in it. I wouldn't say that I was skilled. I would say that it would take a little bit more confidence on my part and I would need support in order to do that personally. … I like to be one step ahead of the children but… tackling areas where I have got no knowledge, I don't know.*

Such a challenging topic requires teachers to become informed and knowledgeable to a level at which they feel confident enough to be able to cope without necessarily having a perfect understanding. It also calls for a change in mind-set for some teachers from viewing their role as solely imparting knowledge to children, to becoming co-learners. Interestingly, Teacher A struggled with wanting to know more about the subject, so she could always be *one step ahead of the children*, yet at the same time acknowledging her role as a co-learner.

Teacher *I am not a font of all knowledge and I tell the children that all the time. If they expect me to know everything then I just say to them 'I am not Google, away and google it!' But you are right, because of course Google is a perfect example. How do we know? How do we sift through Google? I don't know. Maybe I don't know myself. But I don't tell them that I am certain about every piece of information ... They will not view me as that kind of teacher. They will see me as a learner along with them. So therefore, there is an element of, I don't know, trust… that will we will learn together ... They know that I am not an expert in everything. You can't be. You just can't be. Life is just not like that.*

A formidable topic such as global warming affords many opportunities for developing uncertainty competences such as being able to accept not knowing (what will happen or what the right answer/action is), being able to entertain an enquiring mind, being able to prioritise among many urgent issues, and being able to respond in accordance with the underlying probabilities (Tauritz, 2016). Furthermore, when asked if they heard about complex topics like climate change and water pollution outside of school, the focus group children from Classrooms A, C, D and E told me that they heard about such topics through conversations with parents, friends, watching the news on TV or on their tablets, or by listening to the radio. At the same time their knowledge seemed fragmented and included misconceptions. For example, during a whole-class discussion in Classroom A, Ruby asks what global warming is. The teacher decides not to answer herself, but to ask one of the other children to answer Ruby's question.

Ruby *What is global warming?*

Teacher *Okay, does anybody want to answer that question?*

Jenny *Global warming is, the air is getting filled with too much carbon dioxide, so it is melting the ice caps.*

Teacher *What is the warming part, Edgar?*

Edgar *Is it because the ozone layer is melting away so that sun radiation is getting through to the earth?*

The teacher from Classroom A repeated several times during the interview that she believed that the children didn't *have enough knowledge to talk about the issues*. I concur with the point Teacher A made earlier about the need for progressive learning as an important issue in this discussion. Global warming is an incredibly relevant topic, but it needs careful consideration how best to teach about it. One aspect, how the use of language can affect lessons about such a topic, will be discussed in-depth in the following findings chapters.

In Classroom C three different topics were touched upon. The first lesson started out with a focus on wind energy as a renewable energy source. However, during the classroom discussions two other topics, the dying of the sun and the role of birds in the world, emerged and the teacher decided to adjust her lesson plans accordingly in order to incorporate these topics that were clearly generating learning energy. *Emergent* topics arise in the classroom, originating from something either the teacher or a child says or does and generating intrinsic interest in at least some of the children (Jones, 2012).

The topic of the dying sun which emerged in Classroom C is a perfect example of a topic being, at least to a very large extent, *unknowable*. The children were searching on the Internet trying to answer questions like When will the sun die? How will the sun die? and Could people find a way to live on earth without the sun? These questions don't have one obvious right answer that can be found by searching for information. Even the researchers that have studied phenomenon such as the dying of other stars in the universe cannot with certainty say if the sun will die in, for example, four or five billion years, whether it will explode or perhaps be sucked into a black hole. After a child exclaimed that it was impossible to prevent the death of the sun, the teacher answered *There is no way of saving the sun… That is what it looks like for us at the moment. But maybe somebody will come up with some clever idea.* An unknowable topic affords the opportunity to discuss the certainty of knowledge, the limits to our knowing as well as resourcefulness and the curiosity-driven pursuit of knowledge (Barnes, Gause & Way, 2008). It impacts in particular the development of uncertainty competences in the category: Learning to cherish uncertainty. As the dying sun is an example of *unknowable knowledge* but is at the same time a topic that isn't viewed as urgent, it may be suitable for introducing issues of not knowing and being okay with not knowing. From a philosophy of science perspective, one can never speak of 100% certainty (no uncertainty). Yet at the same time, on the basis of the underlying probabilities and the amount and quality of the collected evidence one can, for all intents and purposes, approach certainty. The topic of the pollinators as it was taught by the teacher from Classroom E is an example of the latter, a topic that is supported by so much evidence that it makes no sense to question the factuality of the pollination process. In the following findings chapters I will discuss the need to develop language to be able to talk about the certainty of knowledge with the children and how the teacher's use of language influences the children's language and classroom behaviour.

Immediacy or *urgency* and *personal relevance* are two other characteristics that can make a topic suitable for teaching uncertainty competences. Prinski, Hecht and Harackiewicz (2018) define personal relevance as "a personally meaningful connection to the individual" (p. 12). Kotter (2008) explains that "when people have a true sense of urgency, they think that action on critical issues is needed *now*, not eventually, not when it fits easily into a schedule" (p. 7). Furthermore, he asserts that urgency is a positive drive fuelled by determination to succeed rather than by frustration and anxiety. These characteristics will be discussed employing the topic introduced to the children during the focus group interviews. In each group I read a short story about a village that has a problem with accumulating rubbish for which the villagers are trying to find a solution. They are trying to figure out if they should vote for placing a waste incinerator which brings with it the risk of air pollution. The children are confronted with a dilemma as there are experts who are for, and experts who are against these waste incinerators. Below, I present the story that I read to the five focus groups.

Researcher *In the village of Brigadoon, villagers are arguing about the proposed waste incinerator that would be placed just outside the village* *boundaries. The incinerator would help solve the issue of accumulating rubbish due to the growing numbers of people living in Brigadoon. One group of experts says that burning waste will cause air pollution and will affect everyone badly, and especially children with asthma and older people. Some doctors agree that going ahead with this plan would be very bad. However, some don't agree. They say that the incinerator will make use of modern processes that don't allow any harmful substances to be released into the environment. How would you find out which experts you would believe?*

One of the things I had noticed during the observations was that the children generally did not display strong emotions in response to the topics under discussion. It was as if they were looking at the issues from the outside. However, during one of the focus group interviews a boy called Steve, responded with much more emotion to the topic of air pollution than the other children. When I asked how the children would decide which expert to believe, Steve answered emphatically:

Steve	*It is clear if you already know, because I already KNOW that air pollution is bad for people with asthma, which is me!*
Researcher	*But you don't know if this particular incinerator is going to cause air pollution.*
Steve	*I am allergic to the bad* [air] *and I think I am pretty bad with fire. So they are burning all the stuff and there is no way to dispose of that. Like really stop it.*
Researcher	*Ok, so you don't believe it is possible that the incinerator wouldn't cause… It must cause air pollution?*
Steve	*Unless they put a roof over it, but then it would get really air polluted in there and they wouldn't be able to dump the stuff in the air.*

As Steve has allergies and asthma it is clear that this topic is personally relevant to him and he feels the immediacy of the topic. It can be a fine line to draw between discussing topics in such a way that children would be more inclined to feel emotionally involved without them becoming unduly stressed. As Taylor, Quinn and Eames (2013) point out, topics such as climate change can be very frightening; it requires the teacher's professional judgement as to how to walk that line, acknowledging the urgency of the problem without framing it as a catastrophe. According to Kotter (2008), the challenge is to frame the topic within a world containing serious hazards as well as great opportunities. As personal relevance and urgency depend on individual experience, it is obvious that a teacher cannot always select topics that will create this sense for each child. However, a teacher can consider when selecting a topic how individual children may receive it.

In discussing topics from my study, I set out to show how the characteristics of sustainability topics afford teachers with a variety of opportunities for the development of uncertainty competences. Characteristics that make topics more suitable for the development of uncertainty competences include topics that are: complex, uncertain, multidisciplinary, controversial, dynamic, emergent, contain hidden information or misinformation, are confusing, unknowable, immediate/urgent, and personally relevant.

4.5 Learning activities

Learning activities can be viewed as "activities designed or deployed by the teacher to bring about, or create the conditions for learning" (New Learning, n.d., para. 1). Key to selecting the right learning activities is the pedagogical character and main intent of the activity. With respect to the current study my interest is in which learning activities have the potential to support the development of uncertainty competences in the upper years of primary school. Section 4.5 discusses some of the attributes of learning activities that could foster the development of uncertainty competences. The focus will be on the learning activities selected by the teachers in my study. Section 4.5.1 explores the possibilities afforded by classroom discussions, Section 4.5.2 focuses on small group discussions, Section 4.5.3 examines the potential of inquiry-based learning, Section 4.5.4 discusses the merits of classroom debates and Section 4.5.5 delves into some of the possibilities furnished by crafts and design activities. These learning activities have some distinct attributes and some commonalities; most entail a confrontation with multiple perspectives.

4.5.1 Classroom discussion

All teachers in this study made use of classroom discussions, also referred to as whole-class discussions, in the observed lesson(s). According to Ewens (1986), *discussions* in the teaching literature are often referred to as “a diverse body of teaching techniques that emphasize participation, dialogue, and two-way communication” (p. 77). In comparison to a more lecture-style lesson, an important attribute of a classroom discussion is the active participation of the children in their own learning process (Dallimore, Hertenstein & Platt, 2004). In the present study the chief learning activity took the shape of conversations between the teacher and the children during which the teacher asked most of the questions, though the children also had the opportunity to ask the teacher questions. In classroom discussions the children are asked for their ideas and opinions and challenged to “explain, articulate, or defend their own positions” (Mason, 1996, p. 412). They are also confronted with *multiple perspectives* as the children listen to each other’s conceptions. As reported by Jan and Talif (2017), this kind of classroom interaction involves teachers and children listening, responding, and comprehending as well as negotiating meaning in a shared context. It is in this interaction that children develop new ideas as well as the language to communicate about these ideas.

Teachers select from a variety of learning objectives those they wish to achieve through implementing classroom discussion. Activating prior knowledge (Mason, 1996), engaging children with a topic (Dallimore et al., 2004), developing listening and speaking skills and the use of language for reasoning (Mercer & Sams, 2006), as well as vocabulary development (Beck, McKeown & Kucan, 2013) are typical examples. Teacher A mentioned during the interview that next to giving the children some content knowledge about global warming, she also felt that the discussions were a good opportunity for the children to develop their listening skills. Listening to each other’s ideas respectfully contributes to the development of the uncertainty competences: being able to understand people with different perspectives, and being able to work in teams with mixed knowledge, skills and experience (Tauritz, 2016). Teacher D also conducted a classroom discussion during which he asked questions about the parliamentary debates they had learned about earlier that week. His aim was to activate the children's prior knowledge. He also asked questions about beavers, again activating their prior knowledge as well as giving the children the opportunity to learn from each other. Teacher E mentioned that the children had *prior learning of … the life cycle of plants*, but as it took quite some effort for the children to answer her questions about plant reproduction she voiced concern that teachers don't spend enough time repeating and connecting related content knowledge.

Two classroom examples will be discussed in which the teacher asked two very different types of questions. Classroom discussions can include both unconditional and conditional questions. With the former I refer to questions that seek a single right predetermined answer, whereas the latter concerns questions that are looking for multiple right answers. Teacher E asked unconditional questions as she searched for a specific answer to the question why plants produce flowers.

Teacher	*Right what is the purpose of the flower or is it just to look pretty?*
Children	*No. No. For bees!*
Teacher	*…does a plant produce flowers because they thought oh the bees need pollen and nectar? No. So why do they produce them?*
Child	*Is it to attract bees?*
Teacher	*But why do they attract bees? I am asking why does the plant grow flowers?*
Child	Uh…
Teacher	*Okay, once the flower is pollinated by a bee or another insect … what happens to the flower?*
Child	*It dies.*
Teacher	*It dies, but does the whole of the plant die?*
Children	*No. Yes.*
Teacher	*Think about the fruit trees that are near the gate. They were covered in blossom earlier this year … We have flowers because they are part of the reproduction process of the plant.*

At least some of the children seemed involved in the lesson perhaps because the teacher was asking questions regarding the purpose of flowers, rather than simply telling them that plants produce flowers as part of the reproduction process. Asking the questions may have contributed to the children learning some content knowledge. Children did not have the opportunity to come with creative answers or examine the topic from different viewpoints. The discussion in Classroom E therefore did not offer the children many opportunities in the way of developing uncertainty competences (see Section 5.2.2 and Chapter 8).

I suggest that, in addition to the reasons for classroom discussion mentioned earlier in this section, discussions can be employed with the intent to facilitate the development of particular uncertainty competences. This becomes clear upon examination of an interchange about renewable energy sources between the teacher in Classroom C and the children. The teacher encouraged the children to ask questions and to write them down so that they could revisit the questions when they had more time. The findings suggest that this contributed to nurturing an enquiring mind. During the discussion, the teacher unwittingly introduced the idea that the sun actually isn't a renewable energy source as one day it will die. She tried to move on and stay on topic, but one of the children came back to it. Kate questioned how anyone can know for sure that the sun will die.

Kate	*But nobody actually knows?*
Teacher	*Nobody knows for sure. No. But nobody is that clever that they can definitely tell. And it is a bit like the global warming thing.*
Kate	*Like on the news they think they know it, but they don't actually know*
…	
Teacher	*Sometimes the scientists will tell you one thing and other scientists will tell you something different. So, who to believe?*

By being calm and stating matter-of-factly that scientists don't always agree, the teacher modelled the uncertainty competence being able to accept not knowing what will happen (Tauritz, 2016). It is one of the competences from the category: Learning to tolerate uncertainty. The teacher then asked the class who they would believe.

Matt *Scientists…*

Kate *Scientists because they are smarter.*

Teacher *Do you believe them just because they are scientists?*

Children *No. no... Yeah!*

The teacher helped the children to reflect on their belief that scientists are smarter. In doing this she is helping them to develop the competence being able to reflect on and (potentially) change one's beliefs regarding uncertainty (Tauritz, 2016). It is another competence from the category: Learning to tolerate uncertainty. The question regarding whether scientists should be believed because they are scientists, also directly relates to the ability to judge the credibility and cognitive authority of knowledge sources (Tauritz, 2016). Note that I am not suggesting that teachers should tell their students not to believe any scientists or scientific knowledge in general. I propose that teachers encourage a critical attitude and explain the need to evaluate the evidence and the credentials of the knowledge source (see Section 1.3.2). Teacher C on several occasions during the lessons encouraged a critical attitude towards knowledge authorities, such as scientists and even herself. She expressed an openness to questioning certainty. The teacher then continued:

Teacher *You wouldn't believe everything. How would you know what to believe and what not to believe?*

Kate *I could, I don't know…*

Teacher *You don't know. Would you have to think about it very carefully? You might have to make a list. This is what I do when I can't decide. I make a list of things. Okay pros and cons. And I think, well that's one list, and that's another list and then I have to decide.*

In this fragment, the teacher describes ways in which uncertainty can be reduced. In particular, through enlisting the following uncertainty competences (Tauritz, 2016): being able to find, evaluate and utilise information (*a list of … pros and cons*), being able to judge the credibility and cognitive authority of information sources (*think about it very carefully* [what to believe]), and being able to reason (*that's one list, and that's* *another list and then I have to decide*). To develop these competences the children and the teacher will need to have many more discussions. Nonetheless, these excerpts illustrate how conversations, through the language the teacher employs and the questions that both the teacher and the children ask, can contribute to more than activating prior knowledge or teaching new content knowledge. The language the teachers employ as well as the questions they ask during discussions can have a considerable influence on the nature of the children's answers, questions, language and behaviour. The findings Chapters 5-7 examine the teacher's use of language in more depth.

4.5.2 Small group work

Small group work is a frequently used approach to activate children in the classroom (Orlich et al., 2013); the teacher in each of the five classrooms employed some form of small group work. The small groups in this study usually consisted of two to four children. Drawing on Cohen and Lotan (2014) I distinguish the following potential attributes of small group work that are especially relevant for the development of uncertainty competences: (1) the children need each other's knowledge, experience and cooperation to complete the task, requiring them to develop communication skills, (2) the group works independently and is not continuously supervised by the teacher: the teacher delegates authority to the children who become responsible for their own learning process, (3) the tasks that the children are given are sufficiently complex, uncertain, able to be viewed from different perspectives, have a variety of viable solutions and require the children to critically think as well as use their creativity. During small group work, teachers take on the role of facilitator as they walk through the classroom observing the groups, listening in on some of the discussions, asking clarifying questions and encouraging the children. Next, I discuss two examples of small group work, namely brainstorming and task-directed discussion, in particular with regard to the opportunities they provide for the development of uncertainty competences.

A. Brainstorming

In this study two of the six small group discussion types Orlich et al. (2013) distinguish play a role: brainstorming and task-directed discussions. In Classroom A the teacher began with a brainstorming exercise. She asked the children to *come up with issues that are damaging our planet*. According to De Vos (2006) and Orlich et al. (2013) the main brainstorming rules are: all ideas should be acknowledged and recorded, the ideas should not be judged, combine ideas and build on each other's ideas, and quantity is more important than quality even though all participants are encouraged to think creatively and, in De Bono's (1990) words, "to break out of the concept prisons of old ideas" (p. 8). The goal is to generate as many novel ideas as possible. Teacher A walked around asking the children how they were getting on with the exercise, asking them to explain what they were writing down, and ensuring that they used particular vocabulary when describing the environmental issues. The brainstorm afforded the children with the opportunity to develop three uncertainty competences: being able to use uncertainty as a catalyst for creative thinking, being able to employ lateral thinking and being able to listen to people with different perspectives (Tauritz, 2016).

B. Task-directed discussion

The following assignment in Classroom A was what Orlich et al. (2013) refer to as a *task-directed discussion*. It is characterised by a clearly defined goal (usually selected by the teacher) and the assignment of individual roles (such as a reader, a recorder and a reporter). The children were asked to select six of the environmental issues they had generated during the brainstorm, and order them from most important (doing the planet the most damage) to least important (doing the planet the least damage). The teacher shared with me that giving them this contentious task of comparing environmental issues that are not easily weighed against each other leads to more discussion in the groups. Each group was asked to share with the class what they had chosen as their most important and their least important issues. This activity afforded the children with the opportunity to develop additional uncertainty competences, namely: the ability to understand people with different perspectives, the ability to prioritise among many urgent issues, the ability to reason, the ability to work in teams with mixed knowledge, skills and experiences (Tauritz, 2016). Examining these group discussions, it became increasingly clear how important the development of communication skills regarding uncertainty is (see Section 6.2.2).

Teacher A introduced one more task-related discussion, asking the children to come with suggestions about how to solve some of the environmental issues they had selected earlier in the lesson. See Section 8.4 for a discussion of conditional questions the teacher can ask about solving problems. The teacher walked around asking the children how they were getting on, helping them become more specific in their discussions and argumentation, and responding enthusiastically to their suggestions. This task provided the children with the opportunity to develop uncertainty competences similar to those in the first task-related discussion. However, asking the children to come with solutions also provided the opportunity to develop the ability to use uncertainty as a catalyst for creative action (Tauritz, 2016). This does not mean that task-related discussions all afford similar developmental opportunities. It remains very important for a teacher to carefully design the task-related discussion in relation to the development of particular uncertainty competences. Other examples from my study, such as the task-related discussions introduced by the teachers in Classroom B (making posters based on the text the teacher read) and Classroom D (filling in a form with arguments needed for the debate), afforded fewer opportunities.

Sufficiently complex and uncertain task

In Classroom B the teacher conducted a note-taking activity during which she listed arguments against building dams. When the teacher was finished reading and the children had completed writing down their notes, she introduced a task-related discussion. The teacher asked the children to work in small groups and make a group poster on the basis of their notes (see Figure 5.4). The poster was used as reference for the debate. Although the children made use of each other's notes and worked without direct supervision, the task itself was not complex and it did not necessitate looking at the task from different perspectives or selecting from various solutions. The only uncertainty competence that could be developed through this task was the ability to work in teams with mixed knowledge, skills and experiences. (see Section 5.2.2).

In Classroom D the teacher and the children focused on the topic of beaver reintroduction in Scotland. The teacher divided the group into 14 pairs, each representing a societal group involved in the debate. Each pair was asked to read printed teaching resources and collect the arguments for or against beaver reintroduction relevant for their group. The task itself was not complex, all the information was provided, and although it included the different perspectives of the various actors, each pair represented only one perspective. The only two uncertainty competences that could potentially be developed were the ability to find and utilise information and the ability to work in teams with mixed knowledge, skills and experience (Tauritz, 2016).

Time constraints and the provision of teaching resources

In Classroom D the observed lesson about the reintroduction of beavers was limited to an hour, which meant that the teacher did not have much time available for the children to search for information themselves. In addition, the internet connection was very slow making it impossible for the children to access the websites the teacher had preselected and also searching for other online sources was not feasible within the time constraints (see Section 4.5.4).

Although all the small group discussions seemed to activate the children to a certain degree, they were generally too short to create much depth in the discussions. The Classroom C teacher introduced a task-related discussion during the third lesson. In this case the children had more time to research the topic (dying of the sun or the role of birds in the world). This created many more possibilities for developing uncertainty competences and will therefore be discussed separately in Section 4.5.3 Inquiry-based learning. In some classrooms the children were given information sheets to read and therefore did not have to search for information sources or come up with creative ideas. This limited the number of opportunities those tasks afforded for developing uncertainty competences (see Section 4.6). Another example shows how carefully crafted questions can create more possibilities even when the children have insufficient time to look for resources themselves. In Classroom C the teacher employed several task-related discussions during the first lesson. One of the last tasks revolved around two statements which the children were asked to discuss in their small groups:

1. *Wind turbines are probably the best renewable energy source at present*
2. *Wind turbines are ugly to look at and noisy*

The groups were also asked to consider, *Who could have made the statements? Could they know if the statements were true?* and *How could they find out if they weren't sure?* These three questions offer the potential for a deeper discussion without asking the children to actually go and search for information. The questions encouraged the children to think and discuss issues related to, for example, finding information, assessing the certainty of information and judging the credibility of knowledge sources. These hypothetical discussions can't replace all actual information literacy activities, but they can be employed as a useful supplement.

In summary, for small-group work to be useful for the development of uncertainty competences they require the following attributes: (1) the children need each other to accomplish the task, (2) the children work without direct supervision, (3) the task is sufficiently complex and uncertain, can be viewed from many perspectives, and could be solved in a variety of ways. Task-directed discussions potentially offer more opportunities for the development of uncertainty competences than do brainstorms. Brainstorms on the other hand seem especially suited for developing the ability to use uncertainty as a catalyst for creative action and the ability to employ lateral thinking.

4.5.3 Inquiry-based learning

In this section the focus will be on inquiry-based learning, which can be viewed as a framework for engaging student-centred methods that provide learners opportunities to question and explore, experiment and infer, collaborate and communicate (Buchanan, Harlan, Bruce & Edwards, 2016) as well as to investigate solutions, and create and reflect on new-found knowledge (Savery, 2006). Inquiry-based learning is grounded in the philosophy of John Dewey (2010), who proposed that the learner's curiosity forms the beginning of education (see Section 2.3.3). In the context of this study inquiry-based learning can also be viewed as a more comprehensive variant of task-related discussions. Teachers in my study referred to it as *researching a topic*. It has considerable potential for the development of uncertainty competences. Only the teacher from Classroom C included inquiry-based learning in her lessons. This was in part due to the fact that she conducted the observed lessons in the context of her science topic for which she had already allocated time before being invited to participate in this study. The same attributes that were discussed in Section 4.5.2 with regard to small group work are relevant for inquiry-based learning and the development of uncertainty competences. Divergence from the task-related discussions that were reviewed in Section 4.5.2 is found in the complexity and ownership of the task and the time allocated for completing the task. According to Orlich et al. (2013) "Inquiry is not simply asking questions; it is a process for conducting a thorough investigation…" (p. 281). Orlich et al. (2013) also state that inquiry-based learning can be characterised by many interactions among the learners, the teacher and the teaching resources. Learning to investigate is a process that is learned over time, requiring practice and guidance from the teacher. Initially the teacher often provides resources; however, as the children's skills and knowledge develop, they become able to search for information and learn how to collect and examine data themselves. The children learn how to make inferences and draw conclusions as they set out to answer their central questions. In the following section I examine the inquiry-based learning activity in Classroom C in order to demonstrate the opportunities it afforded for the development of uncertainty competences.

Inquiry-based learning in Classroom C

The science topic in Classroom C had initially been wind energy, chosen by the children from three options. However, during the first observed lesson two new topics emerged from the classroom discussions: *When and how will the sun die? What is the role of birds in the world?* Teacher C felt that a more student-centred approach in which the children could pursue their own questions would create more intrinsic motivation (Stokhof, De Vries, Martens & Bastiaens, 2017) and therefore the focus shifted to these questions. During the second lesson the children engaged in a variety of learning activities (see Sections 4.5.1 and 5.4.2), making them more familiar with the new topics. Near the end, the teacher split the class into small groups and explained that they were going to research either the topic of the birds or the sun. She presented each group with a list of optional research questions and encouraged the children to rephrase the selected question in their own words. In one group a child asked *What* *would happen to space* [if the sun dies and the earth blows up]*?* Suddenly the group came up with lots of *big questions* as they talked about planets being destroyed and the existence of billions of solar systems. Clearly the complex and uncertain topic of the dying of the sun sparked their interest and provided opportunities to develop the uncertainty competence: being able to entertain an enquiring mind (Tauritz, 2016). The development of questioning skills is vital for information seeking as this, according to Stokhof et al. (2017), “requires a conscious effort by the learner to identify cognitive conflicts or knowledge gaps…” (p. 124). The groups were provided with printed resources and laptops. The children were given time to work on their topic. Working together seeking answers to complex questions without an easy right answer provided them with an opportunity to develop the ability to formulate a plan of action to deal with uncertainty (Tauritz, 2016). This learning process requires support from the teacher to develop effective search strategies (Scott & O’Sullivan, 2005). The groups were asked to make a poster or PowerPoint presentation to share their findings with the rest of the class.

Inquiry-based learning affords opportunities for developing uncertainty competences

As the teacher walked through the classroom spending some time with each of the groups, she modelled generating questions and in doing this facilitated the development of the uncertainty competence: being able to entertain an enquiring mind (Tauritz, 2016). In fact, the teacher said the research and the discussions *brought up more questions than they gave answers* and as the lessons proceeded the children *were asking more questions. They were challenging things; they were coming up with their own ideas.* Orlich et al. (2013) remind us that one of the most important aspects of inquiry-based learning consists of the teacher and the children becoming persistent seekers of knowledge, interrogators and ponderers. The teacher mentioned during the interview that only one group chose the bird topic. A clear difference in the learning process between the single bird group and the sun groups was that the latter *were asking more questions … they seemed to fire off each other. Whereas with the bird group, that was a bit more difficult, because there wasn’t anybody … challenging them. Saying ‘Well how do you know that?’* The sun groups were developing their ability to assess what others are communicating about the certainty of knowledge (see Chapter 8).

The teacher from Classroom C told me that in her opinion the children in primary seven generally have the skills to find information, communicate their thoughts and produce presentations as individuals, but still need to learn how to transfer these skills to collaborative group work. The literature is generally less positive and suggests that students from primary through tertiary education need to improve their information literacy skills (Chu, Chow & Tse, 2011; Coiro, Coscarelli, Maykel & Forzani, 2015; Scott & O'Sullivan, 2005). Findings by Chu et al. (2011) indicate that inquiry-based learning can have a positive impact on information literacy skill development. During the observations it became clear that the children were sharing their thoughts and feelings in their groups and tried to listen to the views of others. The children were developing uncertainty competences such as: being able to find, evaluate and utilise information, being able to work in teams with mixed knowledge, skills and experience, and being able to understand people with different perspectives (Tauritz, 2016). The children were also honing their communication skills. As previously mentioned, communicating with others about the certainty of knowledge became a central topic in my study (see Section 6.2.2).

According to Limón (2001), most proposed models that explain conceptual change emphasise the role of some form of cognitive conflict as a pedagogical approach which presents the learner with anomalous data or contradictory information. This confrontation can cause cognitive disequilibrium which Piaget (1952) asserts is an important step in the learning process (see Section 2.2.3). I asked Teacher C how the children handled the contradictory information found on different websites regarding the timeline of the dying sun and what will happen to the earth when the sun dies. Initially she said, *they tended just to go with the one that they found first … It wasn't until everybody else did their presentation and they thought 'oh your information is different from ours', they questioned who was correct.* Some interesting conversations ensued which resulted in the groups that still needed to finish their presentations, making alterations and applying what they had learned from the other groups. Teacher C mentioned that the children got quite good at asking questions about the certainty of knowledge and the ability to judge the credibility and cognitive authority of information sources (Tauritz, 2016). *They were asking: 'Well how do you know that is true? Where is your evidence, where did you find that? And lots of the groups were able to say: Well it was this website or it was that … and they got to the point where they were introduced to referencing which was something they hadn't done before as well. That was a kind of spin off, an added thing; I hadn't really anticipated that that would happen.*

The Classroom C teacher and the children then held a classroom discussion about the question: *Well is anybody correct?* The teacher and the children concluded *that nobody is really right or wrong, because the scientists can't tell because it is a bit of a guess, a crystal ball situation.* This classroom discussion facilitated the development of the uncertainty competence: being able to accept not knowing (what will happen or what the right answer or action is) (Tauritz, 2016). As for what would happen to the sun, *they all came up with the same information, so they were a bit more appeased and happy with that.* They decided *well actually we agree on all of this, we maybe just don't agree on the timescale*. The children were developing their ability to reason. Some of the children did question*: Why don't they know? … particularly Kate and Ross, the people who just always ask 'why?'. Which is great! You want people to question and you want people to ask why. They didn't just sit back and accept that if somebody says it on a website it must be right.* Kate and Ross demonstrated assessing the certainty of knowledge and the uncertainty competences: the ability to judge the credibility and cognitive authority of information sources, and the ability to entertain an enquiring mind (Tauritz, 2016).

In summary, compared to task-directed discussions, inquiry-based learning is characterised by more complex and challenging tasks, it is not only about asking and answering questions, but also about learning how to carry out an inquiry, it requires more time (which is always an issue for primary school teachers), the topic and questions are student-driven, and it offers more opportunities to develop uncertainty competences.

4.5.4 Classroom debate

In this section I will look at some of the possibilities classroom debates afford for the development of uncertainty competences. Classroom debates are another learning activity that can actively involve learners in the lessons and their own learning process (Kennedy, 2007; Oros, 2007; Tessier, 2009). The teachers from Classroom B and Classroom D employed debates in their lessons. Freeley and Steinberg (2009) define a debate as:

> The process of inquiry and advocacy, a way of arriving at a reasoned judgement on a proposition. Individuals may use debates to reach a decision in their own minds; alternatively, individuals or groups may use it to bring others around to their way of thinking (p. 6).

Healey (2012) writes that, independent of the precise format, debates offer opportunities for the enhancement of communication, research, critical thinking, and argumentation and persuasion skills. In the case of Classroom B, one half of the class defended the proposition: Dams are *bad* for people and the environment, while the other half defended the proposition: Dams are *good* for people and the environment. Classroom D enacted a parliamentary debate. The class was divided into 14 pairs, each representing a societal group that was either for the proposition: Beaver reintroduction in Scotland is a good thing, or for the proposition: Beaver reintroduction in Scotland is a bad thing.

Preparing the debate

Omelicheva and Avdeyeva (2008) suggest that the engaging nature of debates can lead to learners expending more intellectual effort on understanding complex concepts and solving complex problems. This, they continue, can in turn lead to learners acquiring better “comprehension, application, and critical evaluation skills” (2008, p. 606) than when they listen passively to lecture style lessons. Formulating clear, logical arguments requires gathering, analysing, synthesising, organising and evaluating information. Kennedy (2009) suggests that debates also demand “prioritizing the relevance and salience of various points within the overall argument” (p. 226). Developing arguments to support one’s team’s perspective therefore carries the potential for developing uncertainty competences such as: the ability to find, evaluate and utilise information, the ability to judge the credibility and cognitive authority of information sources, the ability to entertain an enquiring mind, the ability to reason, and the ability to work in teams with mixed knowledge, skills and experience (Tauritz, 2016). However, in both classrooms the children learned about the subject of the debate during the same lesson in which the debate took place drastically limiting the time available for preparation.

In Classroom B, the children debated about building dams. The teacher worked together with her colleague in the adjoining classroom. During the preparation for the debate a group of children from each class switched classrooms. The preparation for the debate consisted of lecture-style note taking while the teachers read a list of predetermined arguments for or against dams which were accepted as fact by the children. Active assimilation of the information or questions about evidence for the arguments and the credibility of information sources were not encountered during this lesson, thereby limiting the development of uncertainty competences.

In Classroom D, the teacher explained to the children that they were going to prepare for a parliamentary debate about beaver reintroduction in Scotland. They had just the day before learned about this kind of debate when they debated about the reintroduction of wolves in Scotland. During the interview the teacher from Classroom D first described his teaching strategy as *pupil-lead research*, but quickly changed this into *teacher-guided research*. He provided the children with a selection of educational materials supplied by the Scottish Beaver Trial. As the children had only 20 minutes to prepare for the debate, the teacher felt this was the best way to provide them with enough clear arguments for and against beaver reintroduction. As in Classroom B, the children in Classroom D were not given the opportunity to develop their ability to find information and manage uncertain and contradictory knowledge and generally accepted the information without judging the credibility of the knowledge source. Providing the children with all the information they needed for the debate allowed limited room for uncertainty in that aspect of the learning process.

The debate

The debate about dams in Classroom B afforded the children with opportunities to practice their reasoning skills by employing the prepared arguments, listening carefully to their opponent's arguments, and trying to generate counterarguments in the heat of the debate. Healey (2012) explains that even though the children are focused on their own argument, they have to develop an understanding of the strengths and weaknesses of both their own as well as the opposing point of view in order to be able to devise strong arguments and counterarguments. The children also had the opportunity to develop language to communicate about the certainty of knowledge (see Section 6.3.2).

Clive	*Well, the reason that dams are good for farming is, because... Sometimes … the people that control the dams, they will let out some water and then the water can sink into the soil. And the soil gets better.*
Teacher	*Ah, I see, okay. Anna.*
Anna	*Well I agree with Leo and James, because also the construction of dams, while they are being built they can take up beautiful landscape and destroy it. And because so much of the space is taken up animals can die from it.*
Teacher	*Okay, that is a very good point ... Elly what do you have to say for that?*
Elly	*From the dam water that they use they can grow plants instead of killing them.*
Teacher	*So the water from the dam, the reservoir can be used to grow more plants. Okay, has anyone got anything they want to argue against that? Anna?*
Anna	*It will still take many years to regrow.*
Teacher	*Many years, well-done ... Uhm, Amber.*

Amber *Earlier on a lot of people were talking about how expensive they are, but what they have done is they now build them in a triangle shape. So, at the bottom there is a lot more concrete. But as it gets further up it start to use less expensive materials, because the water won't push as hard off there. And as was said they can use the electricity that they make from dams and sell it to other places and get lots of money and they can take the clean water that they have and sell that to other places as well.*

Teacher *Woh, that is a good counter-argument!*

In analysing the transcripts, it became clear that the reasoning of most children during the debate remained fairly rudimentary. They tended to reproduce one or more of the brief arguments for or against dams. Only a few children, such as Anna and Amber in the excerpt, tried to voice an argument in response to their opponent's argument. Something else became clear from reading the transcripts. The strict rules and structure of the debate, with one debate team being in favour and one being against the proposition can lead to binary rather than holistic thinking, a concern raised by Davies and Barnett (2015). Even though the children are listening to different views, the format did not encourage understanding the complexity of the debate about the controversial topic of dams or the search for a compromise. Langer (2016) points to the shortcoming of focusing on a list of advantages versus a list of disadvantages with respect to controversial ideas: "Such an exercise almost invariably falls short of the recognition that each potential benefit may also be a liability and that a disadvantage may become an advantage" (p. 129). This absolute or unconditional way of looking at the issue can prevent the participants in the debate from considering alternative solutions (see Section 2.2.6). The data suggests that debates may be of limited use for facilitating the development of being able to understand people with different perspectives. On the other hand, they do require the children to listen carefully to their opponents and critically assess their arguments.

Oros (2007) reports that, when learners hear their peers express differing viewpoints full of emotion and supported by convincing evidence, this can have a stronger impact on them than when a teacher describes the different viewpoints in a lecture style lesson.

Something interesting happened during the debate in Classroom B, which the children had prepared for in separate classrooms. The children had not actively prepared to respond to their opponent's viewpoints. It wasn't until the debate began that the children heard arguments from their opponents; even though they should have expected these challenging arguments, some became confused as to whether they should be in favour or against building dams. This reflected what happens whenever people with established beliefs and perspectives find themselves confronted with clashing viewpoints that they have not really considered until that moment. The need arises to navigate the uncertainty of what the *right beliefs* are. Bob in Classroom B had participated in the note-taking activity in the classroom where they prepared the arguments in favour of building dams. During the debate, he fervently defended building dams and dismissed any arguments against dams, categorising dams as being unconditionally positive. Interestingly, the teacher described Bob in the following way: *... he doesn't really question anyone in authority at this point so I could tell him the sky is green and he would consider if he was going to believe me or not.* The teacher hints at the fact that Bob needed to develop the uncertainty competence being able to judge knowledge authorities. In fact, she arguably missed an opportunity to talk to him about two teachers, in other words two in principle trustworthy knowledge sources, providing contradictory information. Initially, Bob believed the arguments he heard when he was in the other classroom. However, as he explained during the focus group interview, he started to doubt that the arguments for dams were convincing enough. He mentioned still feeling confused a week after the lesson about the decision he made while voting.

After the debate

The Classroom B teacher did not initiate an elaborate post-debate reflection with the children although some authors such as Healey (2012) indicate that this is an important part of the learning process. These debates can be useful not only to discuss the quality of the arguments and employment of evidence, but also to reflect on how the debate affected the children. The teacher told me during the interview that she had no idea some of the children were still feeling confused days after the debate. A classroom discussion the following day could have provided an opportunity to talk about those feelings of confusion and uncertainty, which could have facilitated the development of uncertainty competences such as: being able to accept not knowing (what the right answer/action is) and being able to reflect on one's beliefs about uncertainty (Tauritz, 2016). Such a discussion could also benefit the development of communication skills to talk about the certainty of knowledge (see Section 6.2.2). During the focus group interview some children from Classroom B shared that they did not know how to judge the relevance of the individual arguments, or how to weigh the ethical consequences that would result from the decision to build or not to build dams. Also in this regard the teacher could have conducted a post-debate classroom discussion to talk with the children about these deliberations, deepening both their understanding of the complexity of the topic about dams as well as of their reasoning processes during the debate.

Although the teacher in Classroom D did briefly talk with the children about what they had learned right after the debate, the children in the focus group shared with me that after they went home, they were still wondering and uncertain about whether or not beavers had really gone extinct in Scotland. Some of them went online to check what their teacher had told them. If the teacher had spoken to them about the confusion they had felt, an interesting conversation could perhaps have ensued, facilitating communicating about the experienced uncertainty as well as the development of uncertainty competences such as the ability to judge the credibility and cognitive authority of information sources (Tauritz, 2016). See Section 6.2.2.

In summary, classroom debates offer opportunities for uncertainty competence development when teachers provide ample time for children to actively search for and assess information needed to support their argument. Post-debate reflection can facilitate developing competences such as being able to reason, being able to accept not knowing and being able to reflect one's beliefs about uncertainty.

4.6 Teaching resources

Teaching resources are the materials and tools the teacher employs to support the children's learning process. Examples are: textbooks, information and work sheets, PowerPoint presentations, videos, teaching software, relevant websites, computers and office supplies. The utilised resources typically correspond to the learning objectives, topic and learning activities the teacher has selected for the lesson. I discuss briefly some of the resources the teachers selected or developed for their lessons and the opportunities for facilitating uncertainty competence development they did or did not afford.

4.6.1 Selection of teaching resources and use of conditional language and questions

The data suggests that for children to learn about managing uncertain knowledge, uncertainty needs to be welcomed into the learning process. Teaching resources can support this process when the language and questions employed therein are written or spoken in language that communicates that something could be true, rather than stating that it is certain to be true; this is referred to as conditional language (Langer et al., 1989). Unconditional or absolute language refers to language that communicates that something is true and factual. According to Van Rossum and Hamer (2010) and Langer (1997) traditional textbooks predominantly contain unconditional language. Arguably, unconditional language has its place in teaching resources as it does not seem productive to question everything. However, it also does not seem productive never to question information that is introduced as fact. When information is presented conditionally, the context-dependant nature of that information is acknowledged (Van Rossum & Hamer, 2010). This invites the reader to actively and creatively process the information - as opposed to mindlessly accepting the information. This issue is key to my research findings and is discussed extensively in this thesis (see Sections 2.4.4 and 5.2).

Teacher A mentioned that the PowerPoint presentation she employed in her lesson (See Section 6.2.3) was retrieved from the Internet. By pure chance the presentation included some conditional language. The teacher was not aware of this, however, and read the text aloud without talking to the children about the uncertainty it contained; in doing so she did not use the resource to its full potential. It seems evident from the findings that to be able to select relevant third-party resources or create teaching resources requires an awareness of the conditional language necessary to conduct a discussion about uncertain knowledge and the development of uncertainty competences (see Chapters 5 to 8).

In Classroom C, the children who studied the dying of the sun used a variety of teaching resources, such as videos from Tick Tack science, BBC Bitesize and YouTube. The children encountered contradictory information in the videos and from various websites about the ways in which the sun might die, as well as the possible timeline for when this event might take place. Only a few of the websites contained conditional language. Interestingly though, despite the language used in any one place, the contradictory information on the different websites demonstrated the *conditionality* and therefore context-dependant nature of this knowledge. This became most apparent when the children presented their findings to each other and presented contradictory outcomes (see Section 4.5.3). The teaching materials that Teacher C compiled herself unintentionally contained a mixture of unconditional and conditional language. The children were also provided with the textbook: *When will the sun go out? And other strange solar system science* (Thomas, 2012). Langer (2000) points out that scientists know that their findings are probably only true in circumstances similar to those met with while developing and testing the theory. However, as soon as theories are written down in textbooks or teachers talk about them in schools they tend to be transformed from conditional statements into unconditional ones. The book the children were using is a good illustration. It states, for example: “Our Sun has five billion years left” (p. 4). The uncertainty has seemingly disappeared. We still have a lot to learn about a productive balance of conditional and unconditional language in teaching resources.

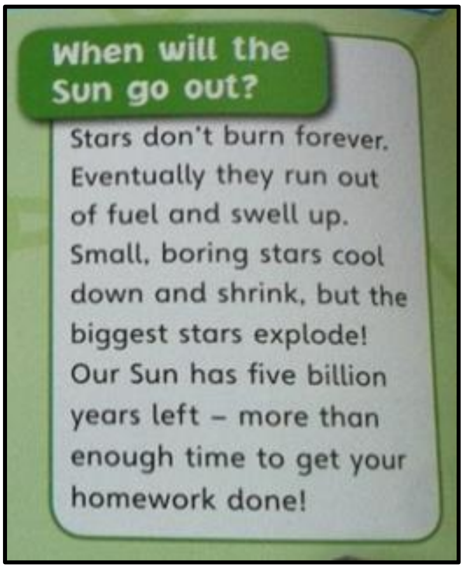

Figure 4.2: Selection of page 4 from the book “When will the sun go out? And other strange solar system science” (Thomas, 2012)

4.6.2 Teaching resources, time constraints and availability

Time constraints are perhaps one of the trickiest challenges for teachers. This includes the time teachers need for the preparation of their lessons as well as the time available for the lesson itself. The teachers all mentioned how much time it takes to find useful websites, information sheets and work sheets online. Teacher A described the internet as *a minefield, it is an absolute minefield!* In the end she selected teaching resources that were made by a teacher who offered them online to other teachers. Teacher A felt she didn't know enough about the topic of global warming and therefore did not question the content of the presentation. *It is an area of the curriculum I am not 100% sure about… I just trusted that that PowerPoint was the truth.* She shared that she *used specific websites that provide resources* such as *primaryresources.co.uk* and that she trusted the content *because it is teachers like me that are struggling to manage the curriculum and they have taken time to produce a resource and are willing to share it. The curriculum is huge. We have to depend on sites and borrow other people's resources.*

Some of the teachers in this study shared that they did not know where to find teaching resources for teaching about complex and contradictory issues. The teacher from Classroom C told me, for example, during the interview that it is *very difficult to find resources that will help you to teach children 'what* [information] *do you believe and what do you not believe'. You kind of stumble across them by mistake generally or the children just raise the questions and you have to then go and find stuff. But there is not very much out there.* There are many teaching resources that deal with critical thinking skills that can be useful for the development of related uncertainty competences such as the ability to find, evaluate and utilise information, the ability to judge the credibility of knowledge sources, and the ability to reason (Tauritz, 2016). However, for other uncertainty competences such as the ability to use uncertainty as a catalyst for creative action, the ability to reflect on one's own beliefs regarding uncertainty and the ability to accept not knowing this does not seem to be the case (Tauritz, 2016).

As was mentioned in Section 4.5.4, the teachers in Classroom B and D who conducted classroom debates were limited by time constraints during the lesson, and therefore provided their children with all the information needed for the debate. In Classroom

D, there were also issues with slow internet connectivity causing the children to lose a lot of time waiting for webpages to open. In the end they only used the printed materials the teacher had provided. Limited internet access is an important practical limitation for the selection of teaching materials. In both classrooms the children were limited in their interaction with the teaching resources and did not learn to navigate materials about a controversial topic. Other time constraints are imposed by the sheer quantity of material contained in the curriculum.

4.7 Summary

In this first findings chapter, the focus lay on defining a teaching strategy that was both data-driven and provided insight into the choices a teacher can make as to how to facilitate the development of uncertainty competences. Creating a teaching strategy often begins with the teacher making a decision about which learning objectives will be addressed. Learning objectives are clear statements of what the learner should have learned by the end of the lesson as well as how that will be assessed. The findings from this study suggest that if the aim is to teach the breadth of the uncertainty competences, and not only the more familiar competences that are closely linked to, for example, critical thinking skills, teachers also need to make these competences explicit in the lesson plan. Some topics afford more opportunities for developing uncertainty competences than others; characteristics that render them more valuable in this respect are for example, complex, uncertain, inter-disciplinary, immediate, personally relevant and unknowable. Many sustainability challenges have these same characteristics. Learning activities provide a varying array of opportunities for the development of uncertainty competences. This study explored the activities chosen by the participating teachers. Task-directed discussions, inquiry-based learning, and classroom debates seemed especially promising. Teachers in this study were not aware of the presence or absence of conditional language in the teaching resources they developed themselves or in the ones that were made by third-parties. However, as was illustrated while discussing the teaching resources, the deliberate employment of conditional language and questions may in itself provide opportunities for the development of uncertainty competences. This will be explored in-depth in Chapters 5 through 8.

Chapter 5 Teacher's use of conditional language

> In most educational settings, the "facts" of the world are presented as unconditional truths, when they might be better be seen as probability statements that are true in some contexts but not in others. What happens when this uncertainty is allowed in? Does the uncertain information become more available to us later, when the context has changed?
>
> (Langer, 2014, p. 117-118)

5.1 Introduction

In this chapter I present the argument that to be able to talk about uncertainty and complexity children need to develop language to communicate about these issues. Central to my case is the concept of *conditional language*. The findings suggest an interesting relationship between the use of such language and the opportunities for the development of uncertainty competences in the classroom. Language is positioned as one of the five key elements of the teacher's strategy (see Figure 4.1). In Section 5.2 I clarify the terms conditional and unconditional language and show how they relate to uncertainty competences. In Section 5.2.1 I examine the differences in the observed classrooms with respect to the language the children used to see if this could be linked back to the teachers' use of (un)conditional language. In Section 5.2.2 I look into a another relationship, this time between the children's classroom behaviour and the teacher's use of conditional and unconditional language.

5.2 Conditional and unconditional language

Among the lenses that I have employed in analysing my classroom observations are Langerian mindfulness theory (see Section 2.2.6) and my theoretical models regarding the development of uncertainty competences (see Section 2.5). The concept of conditional language is elucidated in Section 2.2.6. In short, unconditional language refers to communicating as if something is true and factual. Conditional language in turn refers to communicating as if something could be true, rather than stating that it is certain to be true. Table 5.1 below presents some examples from the classroom observations of questions and statements that were framed as either conditional or unconditional.

Unconditional or absolute language	**Conditional or probabilistic language**
Global warming is human-made.	Global warming might be caused by humans.
How does the process of global warming work?	How might the process of global warming work?
What caused beavers to go extinct?	What may have caused beavers to go extinct?
I teach you the facts, the truth.	Just because I said it, doesn't mean it is true.

Table 5.1: Examples of unconditional and conditional language from the classroom observations

In Section 2.4.4, I discussed how Langer (2014) associates the teacher's use of conditional language in the classroom with a more critical attitude towards information, more sensitivity to context, a more creative state of mind and the inclination to look at issues from multiple perspectives. These key qualities of what she refers to as *a mindful state* (Langer, 2014) clearly relate to uncertainty competences, those skills, strategies, knowledge and attitudes that support the individual in handling complex and inherently uncertain situations (Tauritz, 2016). The relation is clearest in connection to the categories *learning to cherish uncertainty* and *learning to tolerate uncertainty* (see Section 2.3.3). Table 5.2 below provides an overview of the uncertainty competences that most closely relate to the qualities of a mindful state. It is logical to assume that teaching approaches conducive to the development of these qualities will also be relevant to the development of the related uncertainty competences. See Section 2.5 for more information about uncertainty competences. Two sub-themes relating to the use of unconditional versus conditional language emerged from the findings. Section 5.2.1 focuses on the first sub-theme: Teachers' and children's use of (un)conditional language, and Section 5.2.2 looks at the second sub-theme: Conditional language and mindful classroom behaviour.

Learning to cherish uncertainty
▪ Being able to use uncertainty as a catalyst for creative action ▪ Being able to entertain an enquiring mind ▪ Being able to employ lateral thinking
Learning to tolerate uncertainty
▪ Being able to accept not knowing (what will happen or what the right answer/action is) ▪ Being able to reflect on and change one's beliefs regarding uncertainty ▪ Being able to understand people with different perspectives

Table 5.2: The uncertainty competences (Tauritz, 2016) that most closely relate to Langerian mindfulness theory

5.2.1 Teachers' and children's use of (un)conditional language

Central to this first theme are these questions: Is the teacher's use of conditional language reflected in the children's language? and Will more conditional instruction by the teacher lead to more conditional language being used by the children during the observed lesson and during the focus group? Table 5.3 below provides an overview of the three distinguished categories of the teachers' language use in relation to the language used by the children. It shows that the children tended to use the same words and phrases the teacher was using. However, despite the children using some language similar to the teachers, a tendency to use unconditional language was observed in all groups. It is perhaps not surprising to hear much unconditional language in the classroom, as many of today's school systems remain focused on "indicators, measurement and metrics" (Livingston, Schweisfurth, Brace & Nash, 2017, p. 260). According to Paul (1995), most teaching in schools revolves around teachers passing on information to learners, telling them what to believe and know. Information is typically memorised and uncritically passed back during exams. More recently similar assertions have been made by Paul and Elder (2007), National Council of Teachers of English (2014) and Rondamb (2014).

Teacher's use of language	Children's use of language
Predominantly unconditional language (Classrooms A, D, E)	Predominantly unconditional language (Classrooms A, D, E)
Mixture of unconditional and conditional language (Classroom B)	Mixture, but tendency towards unconditional language (Classroom B)
Mixture, but focus on using conditional language (Classroom C)	Mixture, but tendency towards unconditional language (Classroom C)

Table 5.3: Teacher's and children's use of (un)conditional language

Teacher employs predominantly unconditional language

The first category comprised classrooms A, D and E, where the teachers habitually used unconditional language (see Table 5.3). For example, when the teacher from Classroom A explained how burning too much fossil fuel is causing global temperatures to rise, resulting in more fluctuations in the weather, and when the teacher from Classroom E presented the information about pollinators as facts. Some topics, like the process of pollination, are more likely to be presented unconditionally (see Section 4.4). Few people would doubt the process of pollination, although our understanding of the world is ever-evolving, and our ideas about facts are often contested. As Taylor, Quinn and Eames (2013) explain, theories are held tentatively, as best explanations available of how the world works. For practical purposes there exists at any given time a body of knowledge that is generally agreed to be factual. Simultaneously, the scientific community accepts and even welcomes the concept of *being wrong*, as this could lead to better developed theories and understanding. Still, there can be merit in declaring some things as unconditional from a *utilitarian perspective*; in a classroom setting this is dependent on factors such as age and educational level. In order to be able to act upon information, the information sometimes needs to be judged as good enough to be allowed the (interim) status of fact. For example, the teacher from Classroom C, who often encouraged the children to ask questions, chose during the second lesson to stop a child questioning what type of celestial body the sun is and instead, to focus on the impact the dying sun would have on the survival of humanity.

Teacher	*The sun is a star and they have a certain life span … [it] will burn for so long and then it will just go out. Because it runs out of energy. So, the sun is going to do that … in a few billion years' time or a million years' time …*
Child	*How is the sun a star?*
Teacher	*How is the sun a star? That is another good question. I am tempted to say the scientists tell us it is.*
Child	*It is a planet.*
Teacher	*It is our nearest star. That's why we get our light and heat from it …*

Some topics allow for more knowledge uncertainty in the teaching process, and therefore have the potential to confront children with the uncertainty we want them to learn to manage (see Section 4.4). The children in Classroom E discussed very little while they worked in their small groups. All their information- and worksheets contained unconditional instructions and information. From a Langerian perspective this would suggest that the teaching resources and activities did not have the capacity to encourage negotiation of multiple perspectives and therefore limited the development of new and novel ideas (Langer et al., 1989).

There are a number of contributory explanations for the unconditional language used by the children in this category. In Classroom A, the children discussed in small groups what they identified as the most important environmental issues. The teacher then said *I want you to think about what we <u>could</u> do to try and solve some of those problems. What <u>could</u> we do? What kind of ideas do you have about what we <u>could</u> do?* Langer (2016) points out that when a teacher gives conditional instructions like these a stage is set "for doubt and an awareness of how different situations may call for subtle differences in what we [need to] bring to them [to solve problems]" (p. 15). In other words, one could say that solutions by their very nature are dependent on context. As the question was framed in conditional language, I wondered if the teacher's modelling of this language would be reflected in the children employing more conditional language when solutions were being proposed. Examination of the data, however, showed that the children in all classrooms used largely, though not exclusively, unconditional language. The following interchange takes place in Classroom A:

Child	*We could use some more… renewable ways to get energy.*
Child	*… new solar panel cars!*
Child	*They would be so cool.*
Child	*… more electric cars.*
Teacher	*But remember electricity at the moment is produced by burning fossil fuels. The electricity, it would need to be…*
Child	*Only powered by the sun.*
Child	*What about a windmill car? That would be so cool!*

As the activity involved coming up with solutions for complex problems in a very general sense, and without any requirement to develop the ideas, let alone implement them, it did not lead to *contextualised solutions*. In this example the children in Classroom A are addressing the issue of global warming. Researchers (Langer, 1993; Davenport & Pagnini, 2016) point out that if learners are not sensitive to the specific context for which a solution is sought and are not aware of multiple perspectives, they may miss essential contextual information and remain locked in habitual patterns. Uncertainty competences (Tauritz, 2016) including: being able to understand people with different perspectives, being able to entertain an enquiring mind, and being able to employ lateral thinking are called for. The teacher could have asked: What might we do in Scotland to solve our energy problems?

The teacher in Classroom A used predominantly unconditional language throughout. This teacher was quite focused on getting the children to add particular words to their vocabulary. Earlier in the lesson, one of the focus group girls talked about *cutting down the rainforest*, as one of the important environmental issues that we face; the teacher kept emphasising the word *deforestation.* She asked the girl if she had *deforestation* *down?* The girl responded by repeating *de-forestation* after which the teacher told her one more time *put that down. Put de-forestation down.*

The teacher in Classroom D used unconditional language during the lesson about beaver reintroduction in Scotland. At the beginning of the lesson the children and their teacher had a classroom discussion during which the prior knowledge of the children was activated. The teacher used predominately unconditional language when presenting information about beavers.

Figure: 5.1 Free teaching materials provided by the Scottish Beaver Trial

And also, beavers are quite important in the environment. They do lots of things that no other animal does. So, they do chop down trees, they create these dams, they do lots of things in the environment that no other animal does, so we call it a keystone species. The teacher also used teaching materials provided by the *Scottish Beaver Trial*, including an introductory PowerPoint containing mostly unconditional language (See Figure 5.1). Teaching materials often consist of *factsheets* that are written in an absolute and unquestionable manner (Langer, 2016). Scholars warn that the use of unconditional instructions can lead to a more rigid perspective with the consequence that alternative ideas are not considered (Davenport & Pagnini, 2016; Langer, 2014; Langer & Piper, 1987; Ritchhart & Perkins, 2000).

To summarise, the findings suggest that when a teacher employs predominantly unconditional language, the children will also mostly use unconditional language. When a teacher makes use of conditionally phrased instructions, but uses unconditional language during most of the rest of the lesson, children will still use mostly unconditional language.

Teacher employs a mixture of unconditional and conditional language

The second category encompasses teachers who employed a mixture of unconditional and conditional language, such as the teacher in Classroom B. In Classroom B the children generally used a mixture of unconditional and conditional language, though with a tendency towards unconditional language (see Table 5.3). The teacher from Classroom B had prepared a list of pros and cons of building dams with her colleague prior to the lesson. The children in Classroom B focused in the first part of the lesson on the arguments against dams in preparation for a classroom debate which would take place in the second half of the lesson. The teacher read a self-composed text with the arguments while the children listened and made notes. The text consisted of a rich mixture of conditional and unconditional phrases. Table 5.4 below provides some examples of unconditional and conditional phrases extracted from the teaching materials created by the teacher from Classroom B.

Unconditional	The larger dams <u>are</u> incredibly expensive to build. In times of heavy drought dams <u>will</u> stop functioning properly.
Conditional	While this construction is only temporary, <u>it can</u> have long lasting effects on the environment – and <u>potentially</u> harm or worse still destroy local ecosystems. This debt <u>can be</u> a large burden on the government for a long time.

Table 5.4: Examples of conditional and unconditional phrases in teaching materials created by the Classroom B teacher (The Disadvantages of Dams)

When asked during the interview whether the teacher from Classroom B was aware of the term *conditional language* and whether she had deliberately presented the information as indisputable facts, the teacher shared that she wasn't familiar with the term; in fact, none of the teachers in this study were. She had therefore not been aware of her own use of unconditional or conditional language.

Researcher	*So in presenting information you can make a choice there how certain you are or how much uncertainty, I guess, you can build into it. So, it was very clear obviously in the whole lesson that, you know, there are people for dams and people who are against dams and they have all kinds of reasons for that. The fact that you used, the things that you gathered, that you decided 'this is a good one for the for, and this is a good one for the against' those were expressed without conditional language. Really a fact is a fact. Was that deliberate?*
Teacher	*... No, it was completely... I didn't even consider it. I hadn't even thought. I just had a set amount of time where I had to find the facts and I just rushed and got what I could get my hands on really and I hadn't really considered your point, which is very valid.*

During the lesson the children from Classroom B also used both conditional and unconditional language. However, as in Classrooms A and E, they had a tendency to use more unconditional language. During the debate, most children simply repeated the arguments that the teacher read to them during the note-taking activity regarding the disadvantages of dams. The teacher had framed the arguments as facts.

Interestingly, there were a few children who seemed better equipped to manage uncertainty and not knowing. Instead of framing their arguments as facts they acknowledged that there was knowledge uncertainty. In the following example, Alex, one of the boys in Classroom B, responds to a comment from another child, Bob, in which the latter challenged the notion that dams are dangerous because they cause floods: *… if you think about it that was only one person … the majority of the world doesn't have their crops destroyed every single time…* Bob avoids uncertainty by stating that floods are of no concern as they rarely happen: ... *If we go into the city for a minute here, have you heard of any situations on the news at all where there has been floods at all because of dams?* He also minimises the seriousness of the situation if a flood were to happen, saying it would only negatively affect a few people. Alex acknowledges and does not avoid the notion that people don't know what will happen and that a flood could potentially destroy someone's crops: *Bob you are saying that you have never seen anything on the news, not everything that happens in the world goes on the news. You said earlier that that was one person that got their crops destroyed, but you don't really know that. You said the majority don't, you do not know that.*

Whether the difference in this particular boy's manner of handling uncertainty is due to anything learnt in school is impossible to say. Sorrentino and Roney (2000) suggest in their book *The uncertain mind: Individual differences in facing the unknown* that people's personalities differ in their tendency to approach or avoid uncertainty. An uncertainty-oriented person is drawn to uncertain situations as these are "seen as an opportunity to learn something new about themselves or about the world" (Sorrentino & Roney, p. 4). For certainty-oriented people it is "certainty and maintaining clarity that is important, and confusion and ambiguity are to be ignored or avoided" (Sorrentino & Roney, p. 7). It is perhaps the more certainty-oriented individuals who most need help in developing uncertainty competences (see Section 2.2.5).

During the focus group interview, one of the children in Classroom C mentioned that when given the opportunity to select a topic to research she chose the topic about the death of the sun, because she felt that the bird topic had only one answer. She preferred the more uncertain topic about the wind turbine … *because it would bring up discussion*. From the perspective of certainty orientation theory (see Section 2.2.5) this suggests that she might be an uncertainty-oriented person. Langer, on the other hand expresses the view that the use of conditional instruction has a similar, in her terms beneficial effect on most people.

In brief, the children in this study used mostly unconditional language when the teacher employed a mixture of conditional and unconditional language. During the classroom debate the children tended to repeat the information that had been presented to them as facts.

Teacher employs a mixture of both, but focuses on using conditional language

The third category consists of teachers employing a mixture of conditional and unconditional language, but with special emphasis on conditional language. See Table 5.3 for an overview of the three categories of teacher’s and children’s use of (un)conditional language. Compared to the other teachers in the study, the Classroom C teacher used the most conditional language. She emphasised that we can’t always know things for sure, and that people have their own viewpoints. At the same time, most of the teaching resources developed by third parties (videos, book, etc.) that she used contained unconditional language. Interestingly, the teaching materials that she compiled herself were a blend of conditional and unconditional language. See Table 5.5 below for an example of the mixed language used in the teaching resources compiled by the teacher from Classroom C. The selection and development of teaching resources is examined in more depth in Section 4.6.

Wind turbines <u>can be seen</u> from long distances, and <u>some people do not like</u> the way they look.	Wind power <u>does not cause</u> climate change or pollution.
The land underneath wind turbines <u>can still be used</u> for farming.	The wind <u>does not always</u> blow across the whole of the UK all of the time.
Wind is a renewable resource <u>as long as</u> the wind blows <u>it will never</u> run out.	Wind energy <u>is</u> a cheap way to produce renewable energy.

Table 5.5: Examples of teaching resources containing mixed conditional and unconditional language from Classroom C (Observation day 1)

The Classroom C children used a mixture of conditional and unconditional language similar to other classrooms, even though their teacher used much more conditional language than, for example, teachers from classrooms A and B. The teacher from Classroom C asked the children to discuss in small groups what they thought of the idea of putting wind turbines out at sea. They were presented with two statements, one formulated as unconditional and the other as conditional, and asked to discuss them in their groups. The teacher had not been aware of doing this or what impact it might have on the children.

Do you agree or disagree with these statements? 1. Wind turbines <u>are probably</u> the best renewable energy source at present. 2. Wind turbines <u>are</u> ugly to look at and noisy. Discuss your thought and ideas in your group. You have 5 minutes.

Figure 5.2: Worksheet with statements about wind energy to complement a BBC Bitesize video[13]

In the following excerpt, the focus group children in Classroom C share their opinions about wind turbines. Because of the background noise in the classroom it was not possible to identify each child in this conversation.

Child *I think <u>they are</u> ugly and annoying.*

Child *<u>It depends</u> on where they are located.*

Child *I think that <u>they are</u> ugly <u>but it is</u> better to have something ugly and get more eco-friendly electricity than have something which…*

There appears to be tension between the absolute statement and the opinions and independent thought of the children. The children are confronted by conflicting beliefs and seem *confined* by the unconditional words that were used in the second statement (see Figure 5.2). As they negotiate, they are moving back and forth between wind turbines are ugly and are not really ugly. As they continue their conversation, it becomes apparent that their beliefs are converging.

Child *<u>I don’t really mind that they are</u>, <u>they are not really</u> ugly but it would be cool if they painted spots on them or something.”*

Child *Ha-ha. <u>I would</u> love that.*

Discussions in which children share their opinions on controversial statements and negotiate what their collaborative stance will be provide opportunities for them to

[13] Bitesize videos are educational videos for primary, secondary and post-16 students in the United Kingdom and are distributed by the BBC (https://www.bbc.com/bitesize).

develop several uncertainty competences. Examples are, being able to understand people with different perspectives and being able to reason (Tauritz, 2016). Using conditional language, for example, ‘Some people think wind turbines are ugly and noisy’, might have encouraged even more challenging discussion; it would have brought issues of conditionality to the fore thus necessitating the development of their communication and reasoning skills.

In this study the teacher’s use of a mixture of unconditional and conditional language created space for the children to negotiate perspectives. The teacher also encouraged asking questions. A few children started, during the course of the three lessons, to ask questions challenging the certainty of knowledge and the credibility of knowledge authorities.

5.2.2 Conditional language and mindful classroom behaviour

The second sub-theme focuses on the relationship between the teacher’s language and the way the children approach facts, theories and uncertainty. Scholars (Langer & Piper, 1987; Ritchhart & Perkings, 2000) suggest that there is a positive relationship between the use of conditional instruction in the classroom and the amount of mindful behaviour such as questioning information, being sensitive to context (noticing new details), responding creatively to uncertainty and looking at issues from novel perspectives. These characteristics relate in particular to the uncertainty competences from the category “Learning to cherish uncertainty” and “Learning to tolerate uncertainty” (Tauritz, 2016, p. 94) listed in Table 5.2.

While examining the data closely something intriguing emerged. As was mentioned when discussing the first sub-theme, though the children mirrored the language used by the teacher to a certain extent, generally speaking, they used predominantly unconditional language. However, if we look at *what* they were talking about and not only at the words they used to talk *about* it, the teacher’s language can be seen to be reflected in their classroom behaviour. Table 5.6 below provides an overview of the three distinguished categories of the teachers’ language use in relation to the degree of children’s mindful classroom behaviour.

Teacher's use of language	Children's classroom behaviour
Predominantly unconditional language (Classrooms A, E, D)	▪ Accept and repeat information ▪ Try to give right answer
Mix of unconditional and conditional language (Classroom B)	▪ Accept and repeat information ▪ Try to give right answer
Mix of both, but focus on using conditional language (Classroom C)	▪ Ask lots of questions ▪ Challenge knowledge authorities ▪ Creative answers

Table 5.6: Teacher's language and children classroom behaviour

Teacher predominantly employs unconditional language

The first category comprises teachers who predominantly used unconditional language, as did the teachers from Classrooms A, D and E (see Table 5.6). They typically used unconditional language while asking questions designed to elicit verbal responses regarding retention or comprehension of material previously presented. Similar to what Langer (2014) had found, the children generally accepted and repeated the information the teacher shared with them. When the teacher asked questions the children often seemed to try to give the answer they thought the teacher wanted to hear.

The teacher from Classroom A for example regularly asked unconditional questions which served to establish the learner's knowledge. The questions were regularly unconditionally phrased, asking for the *one right answer*. Orlich et al. (2013) describes these questions as being convergent and explains they are used for recall of specific information. The Classroom A teacher seemed intent on teaching specific terms, such as *global warming* and *deforestation*, rather than discussing a theme in depth.

Teacher — *Do you think that natural disasters are on the increase? Do you think we are actually causing more and more things happening? Okay, so why is that happening? <u>What is</u> it that <u>actually causing</u> that?*

Child — *Winds and stuff change…*

Teacher — *But <u>what is causing</u> that?*

Child *What is it called? Global warming!*

Teacher *Get it down* [on paper]. *You've got global warming down, okay. So, what is happening is, is that the earth is warming…*

Child *…and it is causing more natural disasters.*

Teacher *Yeah …*

The teacher from Classroom D explained to the children that they were going to prepare for a classroom debate with the topic beaver reintroduction in Scotland. He then provided the children with the arguments they needed to use during the debate. During the debate children from Classroom D typically repeated the information that had been presented to them as facts by their teacher. For example, Ronald stated the following during the debate: *Thank you presiding officer. We are for visitor's attractions and we are for beaver reintroducing and we think that wildlife people would like to come back if they saw beavers in the wild*. This corresponds with the information from the stakeholder information sheet in Figure 5.3 below.

Figure 5.3: Stakeholder background information provided by Classroom D teacher

The teacher from Classroom E also asked many leading questions. The unconditionally phrased questions prompted guesses from the children as to what the answer was that the teacher wanted to hear. These questions with one right answer did not seem to encourage the children to be creative or look at the topic from different perspectives.

The absence of uncertainty and use of questions with one right answer provided few opportunities to develop uncertainty competences (see Section 8.2).

Teacher employs a mixture of unconditional and conditional language

The second category is made up of teachers using a mixture of unconditional and conditional language. As indicated in Table 5.6, the children in Classroom B displayed a behaviour pattern similar to children in the classrooms where the teachers used predominantly unconditional language. The children from Classroom B generally repeated the information the teacher had provided during the note taking exercise. Interestingly, the teaching materials that the teacher had compiled herself mixed unconditional and conditional language. The language that the children used for their posters displayed similar patterns. See Figure 5.4 below for an example of a poster. Some of the phrases that were used were: *Kills fish! Dams <u>are</u> very expensive to build. People <u>can</u> lose their land <u>when</u> dams are being built. The construction of dams <u>can</u> destroy beautiful landscapes and kill animals. <u>When</u> dams break, <u>they are</u> extremely expensive to fix!* At this point it is questionable whether or not the children were mindful of the conditionality of what they were saying or were simply repeating what the teacher had read to them.

Figure 5.4: An example of a poster a group of children made in Classroom B

In the following exchange, however, it becomes clear that the children were basically repeating the information the teacher had provided. They used the posters as reminders of their arguments during the debate.

Mark	*Dams can cause earth quakes and disruptions to our plant. I can affect people, the earth, and wildlife, technically everything.*
Teacher	*Good argument, who would like to respond to that? Yes, Ben.*
Bob	*I agree with where you are coming from, but if ... a dam does overflow and floods all the land and harms all crops ... Lots of people go to see dams and enjoy watching dams ... lots of people go to new hotels and to restaurants, which allows for much more jobs for people whose land has went away. So, you get more profits.*
Child	*Yeah, I see your point ... people go to see dams, but not only are they entertaining, they are very, very dangerous, expensive and they can destroy ecosystems as well. They can actually tear them apart.*

The children in Classroom B did not question the information presumably because it was the teacher who had provided it. However, there was some confusion when the children suddenly heard the arguments of those classmates that had prepared in the other classroom. They all thought they had *the facts* and knew why they were for or against the building of dams. Then they heard valid reasons from the other group. Section 4.5.4 examines in more detail the use of debates for developing uncertainty competences.

In summary, in the classroom where the teacher used a mixture of unconditional and conditional language, the children also seemed to uncritically accept the teacher's information which was reflected in the tendency towards more unconditional language both in the posters they made and during the debate.

Teacher employs a mixture of both, but focuses on using conditional language

The third category consists of teachers who employ a mixture of both conditional and unconditional language, but with more emphasis on conditional language. Scholars (Davenport & Pagnini, 2016; Langer & Piper, 1987; Langer et al., 1989) have found that teaching students in a conditional manner leads to more questioning of information and more creativity with regards to problem-solving. As depicted in Table 5.6 the children in Classroom C asked more questions, sometimes challenged knowledge authorities and came with more creative answers than the children in the other classrooms. During the first lesson the teacher and the children talked about renewable energy sources, like wind energy and solar power. Inadvertently the teacher asked the children if the sun would last forever. Some children shouted:

Children	*No!*
Child	I*t's got five billion years.*
Teacher	*It is a long time. Should we be worried about that, because we will be dead long since?*
Child	*Well that will be the end of the world*!
Child	*Will it* [the sun] *go into a black hole?*
Child	*How will the sun die?*

The teacher responded enthusiastically with *Oh a big question!* She encouraged the children to write their questions on the back of their work sheets, so the class could come back to some of these *really good questions* later. The teacher recognised the curiosity and the learning energy the question about the death of the sun had generated. She decided to capitalise on that during the subsequent lessons. Curiosity has often been recognised for its potential to enhance the learning process (Litman, 2005; Loewenstein, 1994; Tauritz, 2012a; Von Renesse & Ecke, 2017). Such enthusiasm on the part of the teacher as well as her use of the children's questions in the subsequent lessons can contribute to the development of the uncertainty competence being able to entertain an enquiring mind (Tauritz, 2016).

The teacher from Classroom C encouraged questioning knowledge and knowledge sources during the first observed lesson. In subsequent lessons a few children who had previously said that they would believe scientists because *they are known to be smarter*, started to challenge scientists. One girl in particular said *How DO you know that it* [the sun] *is going to die?* The teacher answered *Well, some of the scientists* *predicted that it will.* Upon which the girl responded with *But, how do they actually know?* By using conditional language and modelling questioning knowledge sources, the teacher provided opportunities for learning uncertainty competences, such as being able to judge the credibility and cognitive authority of information sources (Tauritz, 2016).

The children in Classroom C discussed the way in which the sun might die. They also speculated about whether or not people can prevent it from happening and what would happen to people if the death of the sun could not be prevented. The teacher talked to small groups of children using a mixture of unconditional and conditional language, while emphasising the latter. The children responded more creatively to uncertainty than children in the other classrooms, coming up with all kinds of ideas, such as g*et a machine to like chuck* [gas] *at the sun* in aid of preventing the sun to run out of gas, s*hine a torch at* [plants] to give them energy to grow if there is no more sunlight reaching the earth. In accordance with brainstorming techniques as discussed by Baruah and Paulus (2008), the children did not focus on one right solution, and instead generally suspended judgement of each other's ideas, making space for many creative suggestions. In line with De Bono's (1971) concept of lateral thinking, the children explored the issue from different perspectives and were actively making new connections between ideas. In other words, the children actively engaged in the development of the uncertainty competences being able to use uncertainty as a catalyst for creative action and being able to employ lateral thinking (Tauritz, 2016). It should be noted, that the Classroom C teacher had also set aside more time for the children to research the topic which provided them with more time and space to explore ideas and come with creative solutions.

5.3 Summary

In this chapter I set out to present the argument that it is necessary to develop appropriate language to be able to talk about the certainty of knowledge and multiple viewpoints, and to develop uncertainty competences. Langer's construct of *conditional language*, which entails stating things so as to say they could be true, but are not necessarily true, seems to provide some promising tools for children and adults to talk about uncertainty and complexity. In addition, it would seem that the qualities that conditional language can stimulate: (1) a critical attitude towards information, (2) sensitivity to context, (3) a creative state of mind, and (4) the inclination to view issues from different perspectives, can be associated with the promotion of uncertainty competences. Examples are: being able to use uncertainty as a catalyst for creative action, being able to employ lateral thinking, being able to accept not knowing (what will happen or what the right answer/action is), and being able to understand people with different perspectives (Tauritz, 2016). Teaching strategies that facilitate the development of conditional language can therefore also be conducive to teaching uncertainty competences.

It is important to note that the teachers in this study were not familiar with the terms unconditional and conditional language, nor the potential influence this kind of language could have on the children until they were discussed during the interview. The findings showed that teacher's conditionally phrased instructions, when embedded in primarily unconditionally written or spoken language, do not necessarily lead to the children's use of conditional language. In classrooms where the teacher employed largely unconditional expressions and asked children questions searching for the one right answer, the children seemed to uncritically absorb and reproduce the information with which they were provided. In classrooms where the teachers used more of a mixture of unconditional and conditional language, children still seemed to uncritically accept most of the information that had been presented by the teachers as facts. This was reflected in their use of predominantly unconditional language in the posters they made and during the classroom debate. In the classroom where the teacher used a mixture of unconditional and conditional language, but with a focus on the latter, children asked more questions about the content of the lessons. They also asked the most questions that challenged the certainty of knowledge. When the same teacher challenged knowledge authorities, a few of the children started asking questions about the trustworthiness of information. The teacher's use of a mixture of unconditional and conditional language seemed to create space for the children to explore multiple perspectives, come with creative answers, and practice how to deal with uncertainty. Finally, the teaching materials used in the study showed that teaching materials produced by third parties contained mostly unconditional language. Materials the teachers compiled themselves contained more of a mixture. The findings indicate that developing their own materials can provide teachers with the opportunity to use language tailored to the objectives of teaching uncertainty competences.

Chapter 6 Vocabulary of Conditionality

I know nothing in the world that has as much power as a word.
Sometimes I write one, and I look at it, until it begins to shine.

Attributed to Emily Dickinson

6.1 Introduction

Chapter 5 described how developing conditional language in the classroom can provide children with the language necessary to communicate about uncertainty, complexity and multiple perspectives. In this chapter I present the new more nuanced concept: *Language of Conditionality*. Section 6.2 describes how the concept of language of conditionality emerged from my observations and delineates the tripartite model I devised to represent it. Section 6.3 furnishes an in-depth description of the first part of the model: *Vocabulary of Conditionality* and illustrate how vocabulary development relates to the teacher's interactions with the children referring back in particular to data from the classroom transcripts. My understanding of conditional language evolved as the analysis phase continued. While examining my data and reviewing the literature, I came to see that the construct of conditional language had not been established in sufficient detail with regard to its linguistic properties.

6.2 Language of Conditionality

The Langerian Mindfulness (Langer et al., 1989; Langer, 1993; Langer & Moldoveanu, 2000) literature seems to suggest that any language that includes uncertainty regarding the truth factor of an issue can be considered to be conditional language. The body of psycholinguistic literature, in particular regarding modal language (Bassano, Hickmann & Champaud, 1992; Coates, 1987; O'Neill & Atance, 2000; Ozturk & Papafragou, 2015; Perkins & Firth, 1991; Wilcox, 1991), provided me with a more specific conceptualisation of how particular words and grammatical structures can be used to express differing degrees of certainty. The linguistic literature does not employ the term *conditional language*; instead it directs attention to modal *language* which is also referred to as *language of modality*, *modality* or *epistemic modality* (Coates, 1987). In addition to expressing (degrees of) certainty and possibility, modality also deals with expressions of willingness, permission, obligation, necessity and ability (Papafragou, 1998; Perkins & Firth, 1991; Wilcox, 1991). My study, however, concerns itself with the certainty of knowledge and it is on this aspect of modality that I will focus. My understanding of the construct of conditional language gradually matured and transformed into the more encompassing concept *language of conditionality*.

The concept language of conditionality amalgamates the concept of conditional language which was discussed in Chapter 5, with the more detailed aspects of modal language that focus on expressing certainty and possibility by embracing a variety of linguistic devices including *modal verbs*, *modal adverbs* (that modify verbs), *modal adjectives* (that modify nouns), *mental verbs*, and *evidentials* (indicate the source of the evidence). Language of conditionality by assisting the expression of degrees of certainty avoids conceptualising conditionality and unconditionality as a duality. The relevance becomes clear when trying to code a classroom excerpt that contains a mixture of conditional and unconditional expressions. It is from the specific combination of utterances that the narrator's degree of certainty of knowledge can be construed. In Classroom D one of the children reads the information sheet that the teacher has provided their group out loud. It provides them with key arguments from the stakeholders they will be representing during the classroom debate they are preparing for.

Child *Some members of the Scottish Rural Properties and Business Association are against the reintroduction of beavers to Scotland. Some of their main points are:*

- *Introduction into the modern environment will necessarily impact negatively on current land uses and practices. The area is managed in many different ways and we feel that having the beaver back will cause many management issues.*
- *There will be potential negative effects on Knapdale Woods, which is a Special Area of Conservation. The Protection afforded to Castor fiber under the EU law would render the SNH "Exit Strategy" either illegal or unenforceable.*
- *We believe that the period of the trial is inadequate to validate any of the results.*

- *Some members of the Scottish Rural Properties and Business Association are against the reintroduction of beavers to Scotland.*

The sentence begins with *some members* which is a conditional phrase, emphasising that not all members agree about this controversial topic. It than moves on to say that these members *are against* which is an unconditional statement. Both conditionality and unconditionality are being expressed in the same sentence.

The text contains a mixture of conditional and unconditional expressions, rendering it impossible to determine if the message as a whole is either conditionally or unconditionally phrased. Attempting to do so would simply not account for the subtle communicatory actions taken by the narrator. The text starts out by stating that the arguments listed against reintroduction of the beaver are not shared by all the members of this association (conditional). The first argument states in no uncertain terms, that introduction of beavers will necessarily have a negative impact (unconditional) on current land use. The sentence after that, however, nuances the statement by introducing the mental verb 'feel' (see Section 6.3). Note the difference between 'we feel that it will have a negative impact' and 'we know it will have a negative impact'. In this way the narrator communicated a lesser degree of certainty of knowledge (conditional) than if the mental verb 'know' had been employed. The second argument is also ambiguously composed. It starts out by stating that there unequivocally 'will be' effects on the Knapdale Woods (unconditional). However, by adding in the words 'potential negative' it introduces a degree of uncertainty to the narrator's position, moderating this potentially contentious utterance (conditional). The third argument begins with the mental verb 'believe', which again provides a balance in relation to the degree of certainty at the end of the narrator's comment regarding the questionable length of the trial period.

As my own language awareness developed during this study, I increasingly saw more nuances in the interactions between the teacher and the children, and I realised how important it is to help children develop their *language awareness*, which Carter (2003) describes as "the development in learners of an enhanced consciousness of and sensitivity to the forms and functions of language" (p. 64). Foley (2017) writes in this respect about critical literacy being more than teaching children the functional aspects of reading and writing, and being in addition about helping them to reflect on the way language is employed in social interactions. Sensitising children to the language of conditionality makes them aware that communication is not neutral and can help them understand the importance of exploring "the ways in which language can both conceal and reveal" (Carter., p. 64) the certainty of knowledge. Mosher and Heritage (2017) assert that the meaning of language is conveyed in the way words are organised through, for example, grammar, as well as in the words themselves. Reading the literature alongside examining the data led to the formulation of the tripartite *model of language of conditionality* (see Figure 6.1 below). It consists of these three parts: v*ocabulary of conditionality* (see Chapter 6), g*rammar of conditionality* (see Chapter 7) and *questions of conditionality* (see Chapter 8). The findings suggest that the conscious employment of vocabulary, grammar and questions of conditionality can be viewed as potentially powerful tools with which a teacher could facilitate the children's development of uncertainty competences.

Figure 6.1: Tripartite Model of Language of Conditionality

6.3 Vocabulary of Conditionality

6.3.1 Words used to explore uncertain knowledge and multiple perspectives

Vocabulary of Conditionality refers to the words needed to communicate clearly and with nuance about the certainty of knowledge, multiple perspectives and complexity. This section reviews the importance of developing the child's oral, reading and writing vocabulary of conditionality. A child's oral vocabulary refers to the words they can comprehend and use in a spoken conversation, whereas their "reading or writing vocabulary" (p. 4) refers to the words they can comprehend and use while reading and writing (Department for Children, Schools and Families, 2008). My focus is on classroom vocabulary usage with attention to the linkage between vocabulary development and the development of uncertainty competences.

6.3.2 Why teach the Vocabulary of Conditionality?

Teaching vocabulary fosters improvement in reading comprehension (Biemiller, 2003; Pikulski & Templeton, 2004; Moghadam, Zainal & Ghaderpour, 2012), listening comprehension (Van Berkel et al., 2013) speaking and writing skills (Milton, 2013) and the development of children's ability to use appropriate language to put their thoughts into words (Bromley, 2002). Four uncertainty competences (Tauritz, 2016)– being able to understand people with different perspectives, being able to reflect on and (potentially) change one's beliefs regarding uncertainty, being able to reason, and being able to work in teams with mixed knowledge, skills and experience– are all reliant on the ability to exchange ideas about degrees of certainty of knowledge.

Two new competences regarding communication emerged through close examination of the data. The first surfaced when the teacher from Classroom D explained to the children that they were going to do another debate. *You talked about wolf reintroduction yesterday. We are going to talk about beaver reintroduction today*. They then discussed what the children already knew and didn't know about beavers. After a few minutes the teacher asked: *Do we have beavers living in Scotland?* A conversation ensued during which the children tried to make sense out of the question the teacher had asked about whether there were beavers in Scotland or not.

Children	*Yes. No. Yes. No!*
Teacher	*Some people are saying yes, some people are saying no.*
Ralph	*I think they are, but I thought we were doing a debate about if they were to get* [reintroduced]…
Teacher	*Interesting. You thought they were, but you're not sure?*
Ralph	*Yeah…*
Teacher	*Rick do you know anything more?*
Rick	*They are Canada's national animal.*
Teacher	*Alright so Canada's national animal. So, they are certainly around in other countries. Yep, but we are still not 100% sure about Scotland.*
Rita	*I don't think they are in Scotland because you said it is a day about reintroducing beavers, which would probably mean that they are not in Scotland.*
Teacher	*Alright. So, you are thinking about the language I've used. Fair enough.* Lilian*?*
Lilian	*I am going against Rita… Just because we are reintroducing them, doesn't mean we don't have already started a little bit.*

The children were struggling to interpret the clues the teacher had given them. A new competence emerged from the data at this point: **being able to interpret what others are communicating about their degree of certainty★[14]**. Although critical thinking skills, as discussed by authors such as Richard Paul and Linda Elder (2011), involve people analysing and judging relevant information, and mention the need for clear communication, the competence that emerged here is more specific in its focus on clear communication about the informant's degree of uncertainty. Unwittingly, the teacher created confusion about whether or not there were beavers living in the wild

[14] This current study continues to build on earlier published work about teaching uncertainty competences. In Chapter 2 I presented a 17-item list of uncertainty competences (Tauritz, 2016). During the data analysis three new uncertainty competences emerged. They are included in the Revised List of Uncertainty Competences presented in Chapter 10 (see Table 10.1). Where they are discussed in the findings chapters they will be denoted by a star.

in Scotland, generating an opportunity to work on developing the new uncertainty competence. Learning to listen critically to a speaker and focus on clues that are given about the degree of certainty of knowledge is an important skill (see Section 7.2). This uncertainty competence helps make sense of what is being communicated and, in doing so, can potentially reduce the level of experienced uncertainty. What seems to have happened by chance in this case could be purposely built into the lesson to stimulate the children to pay close attention to what the teacher is saying and to pay attention to the way in which people express their ideas with respect to the certainty of knowledge.

A second new competence became evident when the teacher from Classroom B initiated a conversation with the children about the advantages and disadvantages of dams.

Teacher	*Just before we go any further though, can we just clarify that everybody knows what is an advantage? Is an advantage a good thing or a bad thing? Jimmy? An advantage?*
Jimmy	*Uhm… a bad thing?*
Teacher	*Advantage and disadvantage. So, is the advantage the good thing, or is the advantage the bad thing?*
Child	*An advantage is the good thing.*
Teacher	*It is the good thing. You are right. So, disadvantage has that 'dis', it has got that prefix before it, okay. So 'dis' means that is not good, so disadvantage and advantage.*

The teacher is teaching the children words which they can use to express different sides of an argument. In doing so they are developing a second new uncertainty competence, namely **being able to express one's own degree of certainty★**. As with the first new competence, this one also emerged from the data. Paul (1995) asserts that "children do not learn how to read, write, think, listen, or speak in such a way as to rationally organise and express what they believe" (p. 295). This limits them in breaking free from "their uncritical absolutism" (Paul, 1995, p. 294). Langer and colleagues (1989) refer to this as *mindlessness* (see Section 2.2.6). Although Paul suggests strategies such as teaching topics and introducing activities that encourage viewing issues from multiple perspectives, he seems to side-step the importance of language, such as knowing the words with which to express differing viewpoints and interpret one's own or someone else's degree of uncertainty, as foundational. These competences are so basic to the discussion of uncertain knowledge and complexity that they can be easily overlooked, but as my findings suggest they are important and can be purposefully taught in the classroom.

6.3.3 Strategies for teaching Vocabulary of Conditionality

In this section the focus is on the strategies teachers in my study employed to develop relevant vocabulary. I examine some examples of useful vocabulary, and I reflect on the differences between classrooms in the number of opportunities they afforded for the development of vocabulary of conditionality, as well as for the development of particular uncertainty competences.

The teacher from Classroom C created a learning environment in which the children were provided with ample opportunities to develop vocabulary germane to situations characterised by uncertainty and contradiction. During the first observed lesson, the teacher asked the children if they remembered which topic they had chosen for the new science project and why they had chosen that particular one. One girl mentioned choosing the topic about wind energy because the multiple opinions of the different people involved seemed most interesting to her. At this point the teacher from Classroom C introduced words that helped her clarify her thoughts.

Teacher *Yeah, that was what you mentioned last week. So do people <u>disagree</u> <u>sometimes</u> about the <u>issue</u> of wind farms and wind energy? So could that be classed as <u>controversial</u>? ... What do you think <u>controversial</u> means?*

The teacher from Classroom C employed various teaching approaches described by Duke and Moses (2003) to expand the children's vocabulary. They included: (1) raising word consciousness, (2) teaching important words, (3) relating novel words to known words, (4) exposing the children to words multiple times. The teacher asked what *controversial* meant, thereby introducing a novel and relevant word with respect to the discussion about wind farms. She associated *controversial* to words the children knew by asking if *people disagree sometimes*. By framing the word controversial in this way, she provided the children with clues about its meaning. She also repeated the word a few times and continued to do so in the course of the lesson. In the following exchange, the teacher explains that controversy involves being aware of multiple perspectives.

Ravi	*You make a <u>decision</u> that is <u>controversial</u>, like there could be two like ways …*
Teacher	*There could be two ways. Okay would you like to add to what you said?*
Child	*Yeah that is like one person could think it is <u>not a good idea</u>.*
Teacher	*Uhum, so it is <u>controversial</u> if somebody doesn't <u>agree</u> with the other person?*
Child	*Brings up an <u>argument</u>.*
Teacher	*It might involve an <u>argument</u> …*

The teacher employed a fifth teaching strategy put forward by Duke and Moses (2003), namely to "teach conceptually related-words" (p. 7). The word group the teacher was exploring with the children revolved around multiple perspectives. However, the teacher in Classroom C, although talking about different words that were all related to the confrontation with multiple perspectives, did not draw explicit attention to *how* the words were related. Beck et al. (2013) state that the more *semantic connections* a person maintains "the more rich and flexible their understanding of words" (p. 14) will be. Even though the comprehension of texts about multiple perspectives could have been further explored, the teacher did make the existence of multiple perspectives explicit. The teacher then moved on to a way in which uncertainty might be resolved or accepted and, in doing this, also introduced additional terms related to the word group.

Teacher	*Ok, and moving forward from that, if there is controversy and there is an argument what might bring the people together again at the end?*
Child	*If we don't choose any of them.*
Teacher	*Making choices. Yeah. Dan, can you think what it might be called? If you are having an argument and you then kind of agree to disagree… or if you come into the middle from where your argument is, what would that be called? … To compromise. Do you know that word? Georgia what would that mean if someone was asked to compromise their opinion about something?*
Georgia	*Like meet in the middle.*
Teacher	*Meeting in the middle. Excellent! That is a very good way of describing it.*

The teacher from Classroom C discussed words that pertained to having different viewpoints (and not one right perspective). The teacher from Classroom A chose to read a PowerPoint (see Figure 6.2) about global warming; though it made use of language of conditionality, this was never explicitly pointed out to the children, thereby limiting the discussion about complexity and knowledge uncertainty.

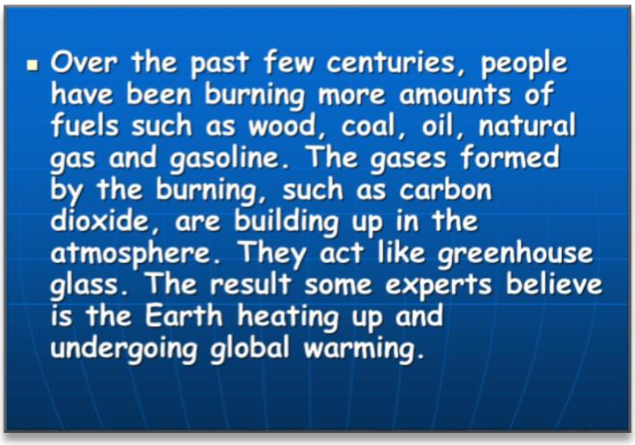

Figure 6.2: An example of a PowerPoint slide from the lesson in Classroom A with information presented in conditional language

During the teacher interview, the teacher from Classroom A reflected on her use of conditional language during the lesson without making this explicit.

Researcher *And if you look at the language that is used in this PowerPoint, there are on several slides, remarks like <u>some experts believe</u> ... or like on the last slide global warming <u>could cause</u>... So, conditional language ... you didn't emphasise this in the lesson. You went through the text with the children and moved on. Were you aware of this*?

Teacher *No, I didn't highlight* [it] *and I know what you are saying. There was an opportunity there to explore that language ... yes. I didn't see it at the time.*

It is arguable that in not highlighting the words used in the teaching materials the teacher from Classroom A missed an opportunity to develop the children's vocabulary related to multiple perspectives.

In Classroom E, the teacher had selected as subject the process of pollination. Due to the general acceptance of the information she provided as factual the lesson did not afford many opportunities to develop vocabulary related to knowledge uncertainty or multiple perspectives. It is important to acknowledge that not all subjects will afford the same possibilities to develop the vocabulary needed to manage knowledge uncertainty (See Section 4.4).

6.3.4 Vocabulary of Conditionality-rich learning environments

During the data analysis, it became evident that *vocabulary of conditionality-richness* is an important characteristic of a learning environment conducive to the development of uncertainty competences. To be able to communicate clearly about the certainty of knowledge, multiple perspectives and complexity, I suggest it is necessary to know and be able to use appropriate words. Bassano et al. (1992) also describe how children develop the use of words and expressions with which they can indicate a degree of certainty or uncertainty. The learner needs to have opportunities to discover new and relevant words and use them repeatedly in meaningful ways (Smith, 2008). Wright and Cervetti (2017) suggest that teaching approaches that involve active processing are generally more effective at teaching the meaning of words than teaching definitions or looking words up in the dictionary. Mosher and Heritage (2017) emphasise that developing vocabulary should be grounded in meaningful contextual experience related to a specific subject and with attention for communicating about that experience (see Section 7.4).

Teachers create a vocabulary-rich learning environment when they themselves employ vocabulary that is at the same time pertinent and varied and includes words and phrases relevant both to the topics and the uncertainty surrounding them. According to Lane and Allen (2010) most researchers, whether they emphasise knowing fewer words well, or knowing many words more superficially, acknowledge the need for both breadth and depth of vocabulary knowledge.

The findings suggest that it is necessary for teachers to consider which words to teach regarding uncertainty and complexity as these words are not necessarily taught in primary schools. The importance of developing the vocabulary and the ability to communicate clearly on these matters has been explained above.

In general the literature appears to suggest the importance of providing teachers with criteria for selecting the most pertinent words, while at the same time respecting the teacher's autonomy and their knowledge of the individual children in their classroom. In 1987, Beck and colleagues introduced a framework that is commonly employed by teachers and researchers for the selection of words most relevant to their teaching objectives. It consists of three tiers of words that play distinct roles in communication, and its objective is to support the teacher's selection of classroom vocabulary without prescribing specific words. *Tier one words* refer to words that are frequently found in spoken language. Children tend to learn these words through conversations in their day-to-day lives. They are easily explained. Examples related to teaching about uncertainty and complexity and used by both teachers and children in my study are: *right, wrong, question, sure, not sure, believe and don't believe*. According to Beck et al. (2013) *Tier two words* are important for comprehension and are frequently used by "mature language users" (p. 25). These words are more precise and help users to become more specific and nuanced in their communication about individuals and situations they are to some extent already familiar with. Examples of words used by teachers and sometimes also by children in my study are: *uncertainty, certainty, probability, opinion, theory, argument, might* and *could*. The third category consists of *Tier three words*, which are specific to particular domains and are generally not encountered in children's every-day lives. These words require more explanation than words from the other two categories. There are no examples of words used during the classroom observations that fit this category. I introduced the Tier three term *conditional language* to the teachers during the interview; none of the teachers were familiar with it. Examples taken from the theory and discourse of my thesis are: *uncertainty competences, wicked problems and super complexity*.

Beck and colleagues (2013) suggest that teachers focus their instruction on Tier two vocabulary. In addition, they suggest that teachers use the following three criteria for selecting appropriate words for the children to learn: (1) "Importance and utility" (words that are frequently used in different domains), (2) "Conceptual understanding" (words that provide the child with the possibility to communicate with more nuance), and (3) "Instructional potential" (words that are used in a range of contexts in which they have different meanings that can be explored) (Beck et al., 2013, p. 28). A good example borrowed from the teachers in my study is the word: *argument* which is used in many different contexts and disciplines and provides the learner with means to be much more specific. For example, 'the neighbours are talking', 'the neighbours are fighting' and 'the neighbours are having an argument'. In addition, 'argument'[15] has various meanings such as an exchange of diverging viewpoints, a reason in support of an idea, etcetera.

The findings suggest focusing on unfamiliar Tier two words that add to children's ability to express their ideas about uncertain knowledge and multiple perspectives, as well as the ability to understand others who communicate about these concepts. Clearly, the role of the teacher in determining the pre-existing vocabulary level of the

[15] The Oxford English Dictionary provides several definitions for the word 'argument': "An exchange of diverging or opposite views", "A reason or set of reasons given in support of an idea, action or theory", "An independent variable associated with a function or proposition and determining its value" (Logic Mathematics), "Any of the noun phrases in a clause that are related directly to the verb, typically the subject, direct object, and indirect object" (Linguistics), "summary of the subject matter of a book" (Archaic). (Retrieved on 13 February 2018, from https://en.oxforddictionaries.com/definition/argument)

children is prominent in word selection. I sought an answer to the question whether or not the children in my study were being taught the vocabulary needed to be able to clearly communicate about knowledge uncertainty, complexity and multiple perspectives. In the context of my observations and analysis of the classroom exchanges, I categorised the words I heard according to Beck et al.'s (2013) three criteria, whilst being aware of the examples they provide to discuss the Tier-framework. I also listened to the interchanges between the teachers and children in my study and logged the relevant words they used and discussed, as well as the words the children seemed to know and the ones they didn't know.

The teachers from Classrooms A and E used distinctly fewer words related to uncertainty and multiple perspectives than the other teachers, as did the children from these classrooms. While the children in Classroom A were working in small groups discussing what the important threats were that harm our planet, the teacher was more focused on teaching the correct terminology, such as *deforestation* and *global warming* than addressing issues of complexity and contradiction. During the observation the teacher told me that the children didn't know *the umbrella terms*. Again, during the interview, the teacher shared her thoughts on the children not having *enough knowledge to talk about these issues*. Her intention was to provide the children with an introductory level of information about global warming. So, although terms such as deforestation can be classified as Tier two, they are not Tier two words that would serve to enhance the children's communication about contradiction and knowledge uncertainty. Though the teacher used some words and phrases that related to multiple viewpoints and uncertainty, they would be categorised as Tier one words, especially for children in P6/P7 (see Table 6.1). Examples of words and phrases the teacher used were:

believe, decide, do you think, least/most important, problem, what could we do, you are right

Table 6.1: Tier one words related to uncertainty used by Classroom Teacher A

Although these words are frequently used in different domains (Criterion 1), they would probably not enhance the ability of most children in this study to express themselves with more nuance regarding uncertainty and multiple perspectives (Criterion 2) and, other than perhaps the word *problem*, which is employed in many domains with different meanings, they also have limited instructional potential (Criterion 3). The Classroom A children used words and phrases such as:

could, I don't know, important, I think, reason

Table 6.2: Tier one words related to uncertainty used by children from Classroom A

The word *reason* could arguably be classified as a Tier two word, the others are Tier one words and phrases (see Table 6.2).

The teacher in Classroom E was very content focused. The teaching materials that the teacher used contained many examples of Tier two words, such as *adapt*, *attract*, *withstand*, *design*, *evolve*, and Tier three words related to the topic of pollination, for example, *stigma*, *style*, *petals*, *pollen*, *cross-pollination* and *nectar*. However, there was hardly any use of vocabulary of conditionality (see Table 6.3). Somewhat related phrases the teacher used were:

why did you choose that, you are right, what do you think that means

Table 6.3: Tier one words related to uncertainty used by Classroom Teacher E

The children in Classroom E did not use any conditional language. The topic as such did not provide much opportunity to talk about uncertainty. In the lessons observed in Classrooms B, C and D a richer vocabulary was employed by the teachers and children, which complemented the complex and controversial nature of the selected topics (See Section 4.4). Both teachers and children in these three classes used more Tier one than Tier two words. The Classroom B teacher taught a lesson about building dams. Examples of Tier two words that she used were:

advantage, argument, attitude, brainstorm, collect and gather evidence, complexity, concede, cost benefit analysis, could become, counter-argument, debate, devastating, disadvantage, evidence, fact, ineffective, irrelevant, I see your point, however, opinion, possibility, precious, present arguments, reason

Table 6.4: Tier two words related to uncertainty used by Classroom Teacher B

The words in Table 6.4 are frequently employed in many domains (Criterion 1) and they provide the children with vocabulary that they can apply in more nuanced communication (Criterion 2). Some of the words, such as fact, opinion, evidence, complexity and reason have a strong instructional potential (Criterion 3). For example, the word *fact* has an interesting variety of definitions. For a philosopher a fact is “a proposition that may be either true or false, as contrasted with an evaluative statement” (Collins Dictionary, n.d., para. 2). In every-day life, a fact stands for “an event or thing known to have happened or existed, a truth verifiable from experience or observation, and a piece of information” (Collins Dictionary, n.d., para. 2). The online Free Dictionary defines a scientific fact as “an observation that has been confirmed repeatedly and is accepted as true (although its truth is never final)” (Free Dictionary, n.d., para. 1). The difference in meaning between the fact of everyday life and a scientific fact can have a significant impact on the discussion of the certainty of knowledge (see Chapter 1.3.2). The teacher’s choice of doing a debate about the advantages and disadvantages of dams afforded the children with opportunities to practice Tier two words and phrases, some of which had been learned during a previous debate. During my classroom observation the children revisited that vocabulary (see Table 6.5). Here are some examples of Tier two words used by the children from Classroom B:

argue, could harm, disadvantage, detrimental, fact, fair enough, I agree with where you are coming from, it can cause, it might not, I see your point, however, precious, put yourself in their shoes, reason

Table 6.5: Tier two words related to uncertainty used by children from Classroom B

Teacher C taught (three lessons) about renewable energy sources. She used many Tier two words when she spoke to the children (see Table 6.6). Some examples of Tier two words that teacher C used are:

advantage, agree, agree to disagree, argument, believe, benefit, big question, brainstorm, complex issue, complex question, compromise, controversial, convince, decision, disadvantage, disagree, dislike, dispute, false, how do you know it is true,

investigate, issue, is that theory true, it depends, magpie ideas, might, nobody really knows for sure, opinion, option, outweigh, persuasive argument, predict, probably, pros and cons, reason, reference, theory, true, uncertainty, understanding

Table 6.6: Tier two words related to uncertainty used by Classroom Teacher C

Again, these words are frequently used in many domains (Criterion 1) and they provide the children with vocabulary that they can apply in more nuanced communication (Criterion 2). For example, 'they were having an *argument'*, 'they were having a *dispute'*, or 'they were having a *brainstorm'*. Some of the words, such as *argument*, *investigate*, *theory* and *uncertainty* have a strong instructional potential (Criterion 3). Table 6.7 provides examples of Tier two words that the children from Classroom C used:

advantage, agree, argue, argument, believe, conflict, disadvantage, impossible, it depends, maybe, meeting in the middle, might, more than likely, opinion, probably, proof, pros and cons, proven, ridiculous, testing, they think they know, true fact, unanswerable

Table 6.7: Tier two words related to uncertainty used by children from Classroom C

The Classroom D teacher taught a lesson about the reintroduction of beavers in Scotland. Table 6.8 below shows some examples of Tier two words that the teacher from Classroom D employed:

argue, argument, back up what you say, benefits, can affect, certainly, costs, could have been, debate, evidence, facts, issue, it could, it might, maybe, moral argument, not 100% sure, other side of the argument, parliament, point of view, positive/negative side, possible, probably, surveying, that might be part of it, tracking, trial, which groups will be affected by

Table 6.8: Tier two words related to uncertainty used by Classroom Teacher D

These are again words frequently used in many domains (Criterion 1) and they provide the children with vocabulary that they can apply in more nuanced communication (Criterion 2). For example, those are the *facts*, that is the *evidence* and that is their *point of view*. Some of the words, such as *trial*, *evidence* and *argument* have a strong instructional potential (Criterion 3). The teacher provided the children with teaching resources that contained information for each stakeholder group represented in the debate. The information included some conditionality related Tier one words, such as *for*, *against*, *important* and *successful*. The sheets also included Tier two words related to uncertainty and multiple perspectives, for example, *benefit*, *concern*, *evidence*, *test*, *decision*, *uncertainties*, *consultation* and *objectives*. Most children only read the information pertaining to their own stakeholder as they ran out of time, even though the teacher said it was important for them to read the other information as well to be better prepared for the debate (see Section 4.4, Section 4.5 and Section 4.6). Table 6.9 showcases examples of Tier two words the children from Classroom D used during the debate:

believe, debate, inadequate to validate the results, issue, it could happen, judge, might, probably, object, objection, represent, vote

Table 6.9: Tier two words related to uncertainty used by children from Classroom D

On the basis of my findings it seems that teaching a vocabulary of conditionality can be enhanced if a teacher creates a vocabulary-rich learning environment that affords children with many opportunities to listen to relevant vocabulary, to discuss the meaning and use of this vocabulary, and to actively use it in a relevant contextual experience.

6.4 Summary

Chapter 6 introduced the concept language of conditionality which amalgamates the concept of conditional language (Langer & Piper, 1987; Langer et al., 1989), with the more detailed aspects of modal language (Bassano et al., 1992; Coates, 1987; Wilcox, 1991) that focus on expressing certainty and possibility using a range of linguistic devices. I argued that children’s language awareness needs to be developed for them to be able to understand how language is being used with respect to the certainty of conveyed knowledge. I also proposed a model of language of conditionality made up of vocabulary of conditionality, grammar of conditionality, and questions of conditionality. My study suggests that being able to communicate about the certainty of knowledge requires acquiring relevant vocabulary and the understanding of grammatical structures that enable individuals to express themselves as well as to understand what others are communicating.

The rest of Chapter 6 focuses on the vocabulary of conditionality. This refers specifically to the words needed to communicate clearly and with nuance about the certainty of knowledge, multiple perspectives and complexity. I suggested that it is important to actively teach the vocabulary of conditionality as it provides the children with the appropriate language to put their thoughts about uncertainty and complexity into words. In fact, two new competences emerged while analysing the data: being able to interpret what others are communicating about their degree of certainty★ and being able to express one's own degree of certainty★.

The teachers I observed employed multiple teaching approaches such as: (1) raising word consciousness, (2) teaching important words, (3) relating novel words to known words, (4) exposing the children to words multiple times, and (5) teaching conceptually related-words. Choice of topic and activities were also observed to afford the children more or fewer opportunities to actively use and explore vocabulary of conditionality. Each teacher selected specific words to be taught. I suggest the value of providing the teachers with criteria with which to select particular words from the vocabulary of conditionality that they think are most relevant for children in their classrooms to focus on. Beck et al.'s (1987) Three-Tier System for Vocabulary Instruction seems particularly useful. Vocabulary of conditionality is only one of the three parts of the model of language of conditionality. Chapter 7 will focus on the grammatical devices that individuals can use to express their degree of certainty.

Chapter 7 Grammar of Conditionality

> A rich educational context is one in which knowing and not-knowing, assurance and non-assurance swirl around each other chaotically; and teaching is as much about communicating not-knowing, tentativeness, uncertainty, flights of fancy, hypotheses, puzzles, conundrums, bafflements and confusions, as it is about communicating knowing, assurance, certainty, well-mapped paths, proofs, solutions, clarification, illuminations and clarities
>
> (Buckingham, 2014, p. 10)

7.1 Introduction

Chapter 7 focuses on the second part of the tripartite model of language of conditionality: *Grammar of Conditionality* (see Figure 7.1 below). Congruous with vocabulary, grammar is one of the building blocks of language. The Farlex Grammar Book (Herring, 2016) defines grammar as "the way words are used, classified, and structured together to form coherent written or spoken communication" (p. 18). With grammar of conditionality I refer to grammatical rules and linguistic devices that enable the author or speaker to express a particular degree of certainty of knowledge in their written or oral communication. Simultaneously, the grammatical structures and words the speaker uses provide the listener or reader with essential information for understanding the message. Chapter 6 addressed exploring modal language to find out more about these linguistic devices and went on to discuss the first component of the language of conditionality, the vocabulary of conditionality. In 7.2 I discuss the use of four modal devices: *modal auxiliary verbs*, *modal adverbs*, *mental verbs*, and the role of *evidentials* in communicating about uncertainty. The findings are based on the recordings from the classroom observations and the outcomes from the interpretive content analysis of the transcripts regarding the communication between teacher and children. The findings were complemented by data from the focus group interviews and the interviews with the teachers. Section 7.3 focuses on employing conditionals in discussing the certainty of knowledge. In 7.4 I briefly look at the possibilities language lessons that are already part of the curriculum provide for the development of the language of conditionality, understanding probabilities and, consequently, the development of uncertainty competences.

Figure 7.1: Grammar of Conditionality

7.2 Modal auxiliary verbs, modal adverbs, mental verbs and evidentials

According to Wilcox (1991) children need to develop an understanding of *relative uncertainty* as well as an understanding of the language being used to communicate about the certainty of knowledge. These abilities are developed during childhood and adolescence, through our social interactions as well as our educational experiences. Learning how to reason logically depends amongst other things on one's ability to understand when conclusions are certain and when they are uncertain (Byrnes & Overton, 1986). As adults we are aware that we are more certain about some beliefs than others, and that knowledge sources vary in degree of trustworthiness. Sometimes information is believed because the knowledge source seems credible and the process of knowledge production seems reliable. Under different circumstances we may ourselves be able to collect empirical evidence that we then base our assumptions on.

Wilcox (1991) goes on to discuss how language provides multiple linguistic devices with which we can express: (1) how certain we are about our beliefs, (2) what kind of evidence we use for our claim, and (3) what our belief state is. During the following interchange both Classroom C teacher and a girl named Kathy use different linguistic devices as they explore Kathy's certainty of knowledge regarding birds flying into wind turbines and dying as a consequence.

Kathy	*Some of them* [wind turbines] *killed birds*.
Teacher	*How do you know that birds can get killed* Kathy*?*
Kathy	*They could get killed if they are like really dumb. Just like fly into it*.
Teacher	*Have you read about that anywhere or have you heard that, did somebody tell you that? How do you know that is true?*
Kathy	*I don't know, I think. I don' know if the 'Windscape*[16]*' is like an actual story about wind turbines.*
Teacher	*Yes… Have you read the story Windscape?*
Kathy	*I have read it about … times*.
Teacher	*And birds get killed in that story?*
Kathy	*No, they just like don't want it because they have heard it.*
Teacher	*So is that a bit of a myth then? Would that be true to say?*

Kathy mentions that some birds get killed in wind turbines to which the teacher responds by asking how Kathy came to this conclusion and how sure she is of it. Wilcox's (1991) first category mentioned above, incorporates devices with which a person could express their degree of certainty by using modifiers such as *modal adverbs*: maybe, perhaps, possibly, conceivably, probably, really, absolutely and certainly, or by using one of the *modal auxiliary verbs* or *modal verbs*: can, could, may, might, would, shall, should, will, must and ought. These words allow speakers "to indicate their attitudes towards the truth value of propositions" (Bassano et al., 1992, p. 390). Kathy repeats that birds can be killed in wind turbines, but shows some caution by using the *modal verb* 'could' instead of saying they 'are killed', and by using a *conditional*; only if the birds are really dumb will they get themselves killed (see Section 7.3). According to Wilcox (1991) modal auxiliary verbs express the speaker's degree of certainty about a belief without explicit reference either to the belief or knowledge state, or to the evidence on which the belief is based. The second

[16] 'Windscape' is a children's book written by Sam Wilding (2012). It is an eco-thriller set on the Isle of Harris, Scotland, that explores the dilemma between the usefulness of wind farms and their impact on the perception of the scenery.

category deals with *evidentials*, expressions that indicate something about the source of the evidence one's beliefs are based on (Wilcox, 1991). 'I read a newspaper article', 'I heard the story from my father', and 'I was a witness at the scene' are all examples of evidentials. The third category focuses on a person's belief state or knowledge state which can be described using *mental verbs*, such as 'I know', 'I think', 'I remember', 'I analysed', and 'I guess'. The teacher asks Kathy what evidence she has for her claim that birds get killed in wind turbines. Kathy shows she is unsure by stating she doesn't 'know', but she 'thinks' it is true. She herself has not seen any birds get killed (which would have been direct evidence), however, she has read the book Windscape (indirect evidence). She is unsure if 'the book is an actual story', but by mentioning it she indicates that she understands that it would make it a much more trustworthy knowledge source if it was. 'Actual story' functions as an evidential. In her turn, the teacher uses the words 'story' and 'myth' to reduce the degree of certainty of Kathy's knowledge regarding the wind turbine issue. This is emphasised again by asking if 'that' (it being a myth) is in fact the truth. The teacher is also asserting her authority and showing that she is certain that what she believes is correct. On the other hand, how she expresses herself is softened by the way in which the modal verb 'would' is being used as a less-than-certain phrase. When the teacher concludes with the words *Would that be true to say?* she demonstrates the employment of a fourth device that Coates (1987) calls negative politeness; it acknowledges the listener's need to draw their own conclusions and to save face.

In the example teacher and child are using a myriad of linguistic devices as they negotiate the truth of Kathy's statement that birds get killed by wind turbines. They are not likely to have been very aware of the way in which they were choosing their words. The findings suggest that teachers can develop children's language awareness by purposefully focusing their attention on these rich naturally occurring classroom teacher-child interactions. Understanding how to employ these linguistic devices as well as understanding how another speaker uses them are important abilities that contribute to the development of the following uncertainty competences: being able to evaluate and utilise information, being able to judge the credibility and cognitive authority of information sources, being able to interpret what others are communicating about their degree of certainty★, and the ability to express one's own degree of certainty★.

Children in the upper primary years in England learn about modal verbs (Department for Education, 2013). It should be noted that where the English national curriculum is relatively prescriptive regarding the grammatical structures children need to learn at each stage of their (primary) education, the Scottish Curriculum for Excellence primarily offers guidelines, providing teachers with relatively more autonomy regarding the content they teach. Some teachers from my study shared that they did not formally teach about the use of modal verbs in primary school. Some, like the teacher from Classroom A, had not heard of the term before.

Teacher	I hadn't heard of modal verbs. I had to google to find out. You're right there's quite a bit of room for autonomy. I feel that Curriculum for Excellence is less about the acquisition of facts. … I think in Scotland we're less concerned with what the various aspects of the language are called but concern ourselves more with the overall effect on the reader, be it greater understanding or pleasure in fictional literature.

Teachers can also deliberately use modal verbs when composing their questions. When modal verbs such as '<u>might</u>' and '<u>could</u>' are used in questions previously phrased unconditionally, 'Who <u>did</u> it?', they become conditional, 'Who <u>might have done</u> it?', presenting learners with more inviting questions that have more than one correct answer (see Section 8.2).

Language of conditionality is multifaceted and a child's understanding of it develops and is refined over time through practice. The teacher can use questions about the certainty of knowledge to enhance the encounters of children with the language of conditionality, in the process familiarising them with the different linguistic devices that are available. It would also provide them with ample opportunities to hone their skills in deciphering these clues. It should be noted that the example above also fits perfectly in Chapter 8, in the section discussing questions a teacher can ask a child about the certainty of information (see Section 8.4).

In summary, as children grow up they develop an understanding of *relative uncertainty* as well as learning about the language people use to communicate about the certainty of knowledge. Learning about linguistic devices such as modal verbs and evidentials can enhance their abilities to express degrees of certainty with more nuance.

7.3 Conditionals

It is generally in secondary school that teachers take the understanding of modal verbs to the next level. At this stage children are learning about the formal use of conditionals. *Conditionals* are employed to consider what could happen, what might have happened, and what we wish would happen. Most phrases using the conditional include the word *if*. These sentences are made up of an *if clause* and a *main clause*:

If this happens, I will or won't do that.

A sub-set of these sentences focuses on situations with possible, yet uncertain, consequences.

If this happens, I or it may/might/could do that.

Mosher and Heritage (2017) suggest that children who are less familiar with conditionals, but are then regularly confronted with them in meaningful contexts, can be alerted "to the possibility that another person can be uncertain or speculating about something that may or may not happen or have happened, and that this is how you talk about such things" (p. 11). It was interesting to learn that some of the teachers and some of the children in my primary classrooms used conditionals. For example, the teacher in Classroom C, a P7-classroom, asked the question: What do you think would be good solutions to this problem [of people disliking the sound and sight of wind turbines]? One of the small groups wrote down the following answer: *We thought it would be a good solution if they put them in the ocean, so they wouldn't spoil the view and to stop the noise.*

In Classroom D, a P6-classroom, the teacher modelled the use of conditionals. He did this without explaining the reason for the language that he used. The children also made use of them. The children had about 20 minutes to research the arguments for the group they were representing. At the end, some children asked the teacher if they were supposed to be for or against beaver reintroduction. The teacher stated matter-of-factly that the arguments they collected and the description of who they represented should have made it clear to them. The Classroom D teacher seems to have used the conditional structure as well as the modal adverb to emphasise that representing a particular group meant that they were, more than likely, either for or against reintroduction of beavers.

Teacher *If you are arguing for the Scottish wildlife trust* [then] *you are probably for beavers. If you are arguing for the tourism industry* [then] *you are probably for beavers. If you are arguing for fishermen* [then] *you are probably against beavers. So, have a think. You should be able to tell from the arguments on your sheet whether you are for or against.*

Several children in Classroom D demonstrated that children in P6 can also master the use of conditionals. The parliamentary debate they held appeared to afford opportunities for practicing the use of conditionals, as there were a number of children using conditionals during the observed lesson.

Child *…We can learn more about beavers if we reintroduce them, because we hunted them into extinction quite a, well a few hundred years ago...*

One boy in particular stood out. Admittedly, his teacher described him as having *a quite developed kind of grasp on things* and as being *very high ability* especially for language.

Child *Oh, ok. Well some fishermen aren't very happy about it because if beavers were making their dams, it could stop the river flowing so well and they wouldn't be able to catch as many fish and stuff.*

The use of a conditional does not always signal the same degree of uncertainty. A sentence that reads 'If beavers make their dams, it could stop the river flowing' uses a conditional and a modal verb. Exchange the modal verb 'could' with the modal verb 'will' and the speaker's expression instantly becomes much more certain: 'If beavers make their dams, it will stop the river flowing'. The modal verb can also be left out 'If beavers make their dams, it stops the river flowing' making the statement even more convincing. The speaker has even more options for choosing the specific degree of certainty he wants to convey. For example, by adding a modal adverb to the conditional and the modal verb will: 'If beavers make their dams, it will probably stop the river flowing'.

Although not a focus of my study, it should be noted that it is not always possible to deduce from grammar and word choice alone, what the degree of certainty of knowledge is. Sometimes, for example, the tone of voice or body language plays a role in establishing what the speaker meant (see Section 10.6).

The grammar of conditionality consists of the use of linguistic devices including modal auxiliary verbs, model adverbs and evidentials, with which the competent speaker can skilfully frame his message with the appropriate degree of certainty. This supports the development of many competences such as being able to reason, being able to evaluate and utilise information, being able to judge the credibility and cognitive authority of information sources, being able to interpret what others are communicating about their degree of certainty ★, and the ability to express one's own degree of certainty★.

7.4 Language of Conditionality supports understanding probabilities

We typically associate maths and science lessons with teaching about probabilities. However, literacy and English lessons focused on developing language of conditionality afford another avenue by which the understanding of probabilities can be facilitated. There is increasing evidence that reading conceptually meaningful texts in combination with acquiring science-literacy and doing science experiments benefits both scientific understanding and language development (Cervetti, Barber, Dorph, Pearson & Goldschmidt, 2012). Even though teaching the use of modal verbs and conditionals is not generally a part of primary education, researchers such as Jones, Langrall and Mooney (2007), and Narcarato and Grando (2014) suggest that it is important to help primary school children to start developing language that will allow them to talk about statistical concepts of probability, things that could or might happen. This is, in effect, language of conditionality. Henriques and Oliveira (2016) also emphasise that being able to understand and use what they call *probabilistic language* is important for making reasoned decisions when dealing with uncertain data. In other words, it is important for the development of uncertainty competences such as: being able to prioritise among many urgent issues, being able to reason and being able to respond in accordance with the underlying probabilities.

In Classroom B, the teacher facilitated a debate about building dams. There are clear for and against arguments, but to be able to respond appropriately, an understanding of the *underlying probabilities* is required. Even if a fact is not judged as being unconditionally true or false, connecting it with the underlying probabilities nuances the *conditionality* of the facts.

Jerry	*It is not just about the crops and the fish and the animals, because people can die from dams breaking … The water could spill everywhere and on cities, it can kill millions of people.*
Teacher	*It can kill millions of people if a dam were to breech or break resulting in a flood. Good point, Jerry! Who's got an argument for that? Mary.*
Mary	*Well, I see your point there, but it hardly ever really happens. Dams don't usually break, because they are made of strong material and also there are hardly any people in the world who get killed by dams.*
Teacher	*So Lee, what do you have to say to that?*
Lee	*Well, some people don't get killed by dams, but some people and houses will get broken down and all the crops will die, but sometimes people and houses and animals, and people will die and get drowned.*
Teacher	*If the dam were to flood. Okay, so it doesn't happen very often, but what Lee is saying has happened. So, we can't say it is not a possibility, because it has happened.*

Talking about the meaning of words and phrases such as 'it can', 'it hardly ever really happens', 'sometimes', 'it doesn't happen very often', 'it has happened', 'it is a possibility', as well as learning to recognise these grammatical structures in written or spoken text, could be useful in helping children become more sensitive to the degrees of certainty of knowledge.

During the focus group interview from Classroom B, the children shared their confusion about whether dams are good or bad. The arguments they were using came from two contradictory knowledge authorities who they trusted, namely their teachers. They were struggling with respect to the arguments for and against dams. They were trying to weigh the number of arguments each group used, the impact of particular outcomes, as well as the likelihood of the occurrence of a dam breaking and the number of people who might get hurt if it were to happen - by no means an easy feat for either a child or an adult.

Carol	*I was quite confused. There is so much good things about having dams, but there is also so much bad stuff about having dams. So, it is like, I am so confused my head is like 'whooh'.*
Bob	*... if you got all your facts and then they might have a stronger side, but if you have valid reasons it might overcome the other point, but they might have more <u>valid reasons</u> than your own. So, it is quite hard ... to try and disagree ...*

Acknowledging the importance of understanding the meaning of words like *validity* and how they are used to influence readers and listeners, I asked Bob what he meant by *valid reasons*.

Researcher	*… And you said that the other side, so the against-dams group, had more VALID reasons… What do you mean by valid?*
Bob	*I mean by that that they had a lot more points and I think there were a lot more kind of towards and up to the point, with more of the other yes-facts.*

Without going into more depth regarding numeracy and mathematics, as this is a subject in its own right, such an interchange does make an interesting point. Literacy and English lessons that focus on developing the language of conditionality carry the potential to teach children the language needed to talk about degrees of certainty and support learning about probabilities in maths and science lessons.

7.5 Summary

Chapter 7 focused on grammar as one of the three parts of the model of language of conditionality. In addition to the vocabulary of conditionality, grammatical rules and linguistic devices provide a speaker with more tools to express a particular degree of certainty of knowledge. At the same time, understanding and recognising the grammar of conditionality provides the listener with clues about the speaker's message.

Five linguistic devices that can be used to create a nuanced framing of the certainty of knowledge were discussed: (1) modal auxiliary verbs, (2) modal adverbs, (3) mental verbs, (4) evidentials and (5) conditionals. Although, teachers in the upper primary years in Scotland are not required to formally teach about linguistic devices such as modal verbs, it is clear from this study that the teachers are modelling their use in naturally occurring teacher-child interactions. They can also be found in the children's oral and written language. This is also true for more complex devices such as conditionals, which are formally taught in secondary schools. The data suggests that teachers could raise the children's awareness and understanding of the language of conditionality simply by highlighting its natural use in the classroom. This can in turn facilitate the development of uncertainty competences such as: being able to reason, being able to interpret what others are communicating about their degree of certainty★, being able to express one's own degree of certainty★, and being able to respond in accordance with the underlying probabilities.

Chapter 8 Questions of Conditionality

> … have patience with everything unresolved in your heart and try to love the questions themselves as if they were locked rooms or books written in a very foreign language. Don't search for the answers, which could not be given to you now, because you would not be able to live them. And the point is, to live everything. Live the questions now. Perhaps then, someday far in the future, you will gradually, without even noticing it, live your way into the answer.
>
> Rainer Maria Rilke, Letters to a Young Poet, 2001, p. 14

8.1 Introduction

The third and final part of the model of language of conditionality: q*uestions of conditionality,* questions that invite uncertainty into the learning process will be discussed in this chapter (see Figure 8.1). I argue on the basis of my observations, that asking questions of conditionality can be considered a principal element of teaching strategies that encourage the development of uncertainty competences. In Section 8.2 I describe questions of this sort in detail. Section 8.3 reveals how a typology of questions of conditionality emerged during the analysis. In Section 8.4 I discuss the types of questions children asked and the kind of responses they received from the teacher. One of my aims in this chapter is to show how rephrasing common classroom questions, as well as asking specific questions designed to stimulate exploration, can facilitate the development of particular uncertainty competences.

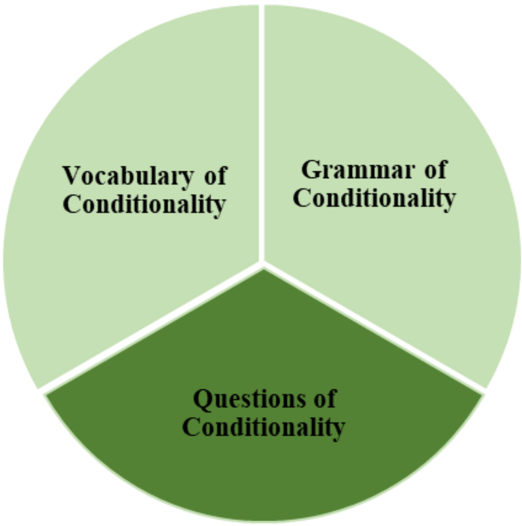

Figure 8.1: Questions of Conditionality

8.2 Description of Questions of Conditionality

The term *questions of conditionality* refers to a variety of questions that invite uncertainty into the learning process. Firstly, they are questions that ask for answers that could be true, but where one correct answer is not anticipated. Questions where the teacher is asking for one or more of a finite number of correct answers, and are therefore not questions of conditionality, are illustrated by the teacher from Classroom D who asked: *Can anyone remember ... what kind of laws the Scottish parliament decides on? Just remember it doesn't decide on all the laws. It only has responsibilities for certain things.* According to Orlich et al. (2013), convergent questions focus on narrow teaching objectives such as the recall of facts and specifics. The children's answers are generally short. In contrast, questions of conditionality are divergent in character, seeking multiple as well as longer responses from the children.

Secondly, the questions are deliberately phrased conditionally to invite the child to explore a concept without penalty, think creatively, develop innovative theories and test alternative solutions (see Section 2.2.6). Compare the following teacher questions: 'What does this mean?', implying that there is a correct answer the teacher is searching for, independent of who is being asked and 'What do you think this could mean?' Ritchhart and Perkings (2008) explain that asking children what they personally think rather than what they know hints at more openness and more than one correct answer. This is emphasised by using the modal verb 'could'. What do *you* think? might run the risk of being interpreted as a test question. 'What could this mean?' might be experienced as more neutral. A conditionally phrased question is not automatically a question of conditionality. Although the words being used are all conditional, tone of voice or body language can reveal if a teacher is actually searching for a pre-established answer. See Section 10.6 for suggestions for further research.

Thirdly, questions of conditionality encourage learners to consider a multitude of answers and perspectives before answering. Paul (1995) emphasises the importance of developing *multilogical thinking*, thinking that considers multiple perspectives when analysing complex multi-dimensional issues, as were some of the topics in the study: *global warming*, *use of renewable energy* and *building dams*. Asking for a personal perspective provides the child with the opportunity to give a unique answer.

Nonetheless, teachers regularly ask children what they think, without really asking for their personal point of view. Teacher E regularly asked questions such as *It tells you on the sheet guys the flowers attract different pollinators. Flowers have different smells, shapes and ... What do you think that means?* The teacher was asking them to recall what they had read on their information sheets. Wragg and Brown (2001) refer to these questions as “pseudo-broad questions” (p. 20). According to them these questions can be very frustrating when a child realises that the teacher isn’t actually asking for creative or imaginative answers, but is instead searching for a pre-determined answer. There is nothing wrong with asking unconditional questions as long as the teacher is not pretending to ask a question of conditionality. Summarising, I suggest that questions of conditionality satisfy the following three conditions:

- don’t ask for one (or more) correct and pre-established answer(s)
- are deliberately phrased conditionally to invite exploration
- encourage learners to consider a multitude of perspectives before answering

In the next section I will discuss a further classification of questions of conditionality.

8.3 Typology of Questions of Conditionality

A typology of eight categories of questions of conditionality (see Table 8.1 below) emerged from the process of analysing the transcripts alongside a review of the literature on classroom questioning (Beghetto, 2016; Cotton, 2001; Dillon, 2004; Orlich et al., 2013; Ritchhart & Perkins, 2000, 2008; Wragg & Brown, 2001; Yang, 2006) and critical thinking (Bloom et al., 1956; Halpern, 2006; Krathwohl, 2002; Paul, 1995; Sternberg, 1986). To structure the questions of conditionality, I selected the format ‘the teacher asks learner about/for/how …’ as this resonates best with my focus on teaching strategies a teacher could employ to develop the learner’s uncertainty competences.

Socratic-based questions of conditionality
1. Teacher asks learner about understanding of a concept/theory 2. Teacher probes the learner's assumptions/beliefs 3. Teacher asks about different viewpoints 4. Teacher probes learner's reasoning process 5. Teacher asks about a learner's strategy for finding information
Uncertainty-based questions of conditionality
6. Teacher asks about the certainty of information 7. Teacher asks learner about beliefs regarding not knowing (what will happen/what the right answer or action is) 8. Teacher asks learner how a problem might be solved

Table 8.1: Overview eight types of Questions of Conditionality

The first five question types are grouped together as *Socratic-based questions*[17]. The question types are derived from Paul's (1995) "questions of clarification", "questions that probe assumptions", "questions that probe reasons" and "evidence, questions about viewpoints or perspectives", "questions that probe implications and consequences", and "questions about the question" (pp. 341-344). The categories that I distinguish in the second group are uncertainty-based. One could say that the focus of the Socratic-based questions is primarily on discovering what is known, whereas the *Uncertainty-based questions* are particularly focused on discovering what we don't know (yet) or can't know for sure. I will discuss both groups using examples from the observations. In Appendix K, I provide a detailed Typology of Questions of Conditionality that includes exemplar questions for all eight question types, as well as the uncertainty competences they address.

[17] "The Socratic Method, a form of philosophical inquiry, or more precisely, a dialectic method of inquiry used by Socrates mainly for the purpose of examining key moral concepts and first illustrated in Plato's early dialogues, is a distinctive pedagogy to encourage people to develop independent thinking by questioning claims about knowledge, to argue about ideas, and to engage in dialogue about important issues of life" (Chesters, 2012, pp. 1-2).

Socratic-based Questions of Conditionality

1. Teacher asks child about the understanding of a concept/theory

Questions the teacher asks children about the understanding of a concept or theory predominated in the question and answer interactions between the teachers and children in my study. They were unconditionally phrased and therefore not questions of conditionality. For example, in Classroom B the teacher talked to the children about what a dam is: *A dam can be big or small. It is a plug in a stream. So, think about your bath. If you put the plug in your bath… what is the purpose of the plug?* One of the children answered: *To stop the water from being drained*. To which the teacher replied with *Exactly. That is what the dam is kind of like. It is a barrier. It is built across a stream or a river and it is to stop or control the flow of water*. These types of questions are closely related to Bloom's (1956) category *comprehension*, in the original Bloom's Taxonomy, and what Krathwohl (2002) refers to as *understand*, in the Revised Taxonomy. Bloom (1956) explains how the focus here is for the learner to "know an abstraction well enough that he can correctly demonstrate its use" (p. 120). Such questions also resonate with the category of the Socratic "Questions of Clarification" (p. 341) as described by Paul (1995). Questions about concepts are rarely phrased conditionally. The teacher is usually seeking a pre-established answer. Although such questions are useful to ascertain the level of retention or understanding of content knowledge (Dillon, 2004), they are less useful with respect to understanding messy real-world problems. There were no clear examples of teachers asking Type 1 questions of conditionality in this study. Hypothetical examples are: 'What could that be?', 'Who might have done that?' and 'Could these statements be described as contradictory?' The teachers in this study predominantly asked unconditionally phrased questions that asked the child about a concept/theory and usually had one correct, pre-established answer.

2. Teacher probes the child's assumptions/beliefs

The second category is made up of questions that ask children about the assumptions and beliefs that fuel their feelings, ideas and actions. Brookfield (2012) describes how when we act we base our choices, often unwittingly, on assumptions that we have accepted in the past. We assume these beliefs to be correct and we use them to interpret the world. He holds that one aspect of critical thinking is the act of intentionally reflecting on our assumptions. Wals, Van der Hoeven and Blanken (2009) underscore that being able to reflect on implicit assumptions is necessary to create space for new perspectives. After identifying our assumptions, the next step might be to determine if they are still valid or if they need to be replaced. The Classroom C teacher talks to a small group about the dying of the sun, encouraging the children to reflect on the theory that they think is the most likely to be true and compare this with what the scientists think is most plausible.

Teacher *Right, <u>you need to find out if that theory is true</u>. <u>Is that really what is going to happen?</u> You could have a slide that says: <u>We think</u> this is what would happen. And then say: Is that actually what scientists believe that will happen? Because nobody really knows for sure. You might be right and scientists might be wrong. But they have investigated it and thought about it for a bit longer than us.*

The uncertain and multi-dimensional topic of the dying of the sun, the format of the learning activities, and the amount of time made available for the children to research the topic created a learning environment in which the discussion about assumptions and theories materialised naturally (see Sections 4.4 and 4.5). The teacher in Classroom C touched on an important issue, namely that as we learn about the world we establish theories which may or may not be true. We are very often not aware of our assumptions and how they inform our actions. Similar to the need for critical reflection on our own assumptions, is the need to critically reflect on the assumptions and theories of knowledge sources, and as Orlich et al. (2013) contend, “suspend judgment until sufficient evidence is presented” (p. 277). The teacher’s questions facilitated the children’s development of many uncertainty competences such as: being able to reflect on and change one’s beliefs regarding uncertainty, being able to find and evaluate information, being able to judge the credibility of knowledge sources (Tauritz, 2016) and being able to interpret what others are communicating about their degree of certainty★ and being able to express one’s own degree of certainty★. The latter two competences were formulated in the course of this study. In conclusion, the findings from this section affirm that uncertain, multi-dimensional topics and learning activities that include enough time for researching a topic can create opportunities for the teacher to discuss the children's assumptions, as well as the assumptions and theories of the knowledge authorities they consult for their project. Brookfield (2012) maintains that one of the ways to assess your assumptions is to view them from multiple perspectives. This directly links to the questions in the third category of questions of conditionality.

3. Teacher asks child about different viewpoints

The third category is comprised of questions about the children's viewpoints. Children all bring their own unique perspectives into the classroom. However, "critical and creative thinking depend on an openness to new ideas and the ability to break out of one's mind-set" (Ritchhart & Perkins, 2000, p. 29). Type 3 questions, according to Ritchhart and Perkins (2000), are important as the ability to consider multiple perspectives needs to be actively developed. In Classroom D, the teacher initiates a classroom conversation about the various groups of people who are going to be affected by the reintroduction of the beaver to the Scottish landscape. The teacher's questions assist the children in understanding how the different actors are affected by the decision in the beaver project and how this leads to different viewpoints on the matter. The children are also practicing their reasoning skills.

Teacher — *What are the <u>benefits</u> of having beavers reintroduced, but what are the <u>costs</u> of having the beavers reintroduced? <u>Who do you think this is going to affect?</u> <u>What groups of people are going to be affected</u> by beavers being reintroduced or not being reintroduced? Rick?*

Rick — *Farmers.*

Teachers — *Farmers. Absolutely, yeah. So farmers are going to have a big say in it, because their land is going to be roundabout where the beavers are living. Ron?*

Ron — *Energy sources or something?*

Teacher *Could be… Yeah, I guess so, if we are still thinking about renewable energy than that could be hydro-electricity as well. So yeah absolutely! Rita?*

Rita *Maybe the people who are allergic to beavers.*

Teacher *I think that that is maybe less of an issue because it is not that we ban dogs, because some people are allergic to them. Ha-ha that is just a problem that people that are allergic need to deal with, really. As long as you don't go cuddling beavers you will be fine. Lucas, anyone else that you think might be affected?*

Child *Lumberjacks.*

Teacher *Lumberjacks. So yeah, forestry people, absolutely. So people that grow forests and harvest forests for wood. And that is a big, big industry in Scotland. Yep, absolutely.*

Although, exploring multiple viewpoints can be considered an attribute of conditional learning (see Section 2.2), and the teacher used some conditional words such as 'benefits' and 'costs' (see Section 6.2.4), he did not initially employ modal auxiliary verbs, such as might, would or could (see Section 7.2). Halfway through the excerpt the teacher does start using 'could' and 'might'. In my study, none of the teachers used conditional language exclusively. Using modal verbs to communicate about the topic would have further emphasised the conditional context of the beaver reintroduction. For instance, the teacher could have asked: 'What might/could be the benefits of having beavers reintroduced?', 'Which groups of people might be affected by beavers being reintroduced or not being reintroduced?'. In summary the observations suggest that when discussing multiple perspectives regarding a complex topic, the use of modal verbs, modal adverbs and mental verbs in formulating questions can emphasise the conditionality of the context. Looking at one's own viewpoint from different perspectives can provide information and reasons upon which decisions could be based.

4. Teacher probes child's reasons

Questions in this category ask children about their reasons for a particular decision/judgement/action and the evidence they have to support those reasons, as well as the possible implications and consequences of decisions and actions. Critical thinking scholars typically agree that making inferences on the basis of inductive or deductive reasoning (see Section 1.2.3) are an essential component of critical thinking (Ennis, 1985; Halpern, 2006; Krathwohl, 2002; Paul, 1995; Sternberg, 1986). The ability to reason is also considered an important uncertainty competence (Tauritz, 2016). During the second lesson in Classroom C the teacher and the children discuss the implications of the death of the sun. The teacher encourages the children to reason through this issue to arrive at a deeper understanding of our dependence on the sun. They also speculate about how humans might respond to the consequences of there no longer being sunlight on earth to grow food.

Teacher	*So we would go hungry, there would be no daylight, no sun, we won't be able to grow food.*
Robbie	*You could just hop in your car and go to the shops.*
Teacher	*But there would be nothing to buy in the shops, Robert.*
Child	*You don't need the sun for everything.*
Teacher	*You are not giving me a solution, as to how we grow, how do we grow wheat to make bread if there is no sun?*
Child	*We don't need bread.*
Child	*Yeah, you don't need that. You can live without bread.*
Teacher	*Okay we don't need bread ... How can we have milk if there is no sun? How would the cows get any grass to eat if there is no sun?*
Child	*If people watered them and put lights over them.*
Teacher	*If people water the grass?*
Child	*They need heat.*
Child	*You could get chocolate!*

Teacher *You couldn't get chocolate either, because chocolate grows on a plant. There would be no plants, no animals*.

The children and the Classroom C teacher are actively engaged in discussing their ideas about life on earth after the sun dies. As they debate this complex and ambiguous topic they employ language of conditionality, in particular modal verbs and conditionals, to express the degree of certainty about their beliefs (Bassano et al., 1992) regarding the plausibility of growing food on earth without the sun. This uncertain and multi-dimensional topic provides the teacher with the opportunity to help the children to develop their ability to reason (Paul, 1995). The teacher is also demonstrating to the children how to entertain an enquiring mind by asking probing questions. It is clear from this example that the teacher is encouraging the children by taking their responses seriously and addressing them with respect. The ambiguous topic, the use of language of conditionality and the respectful and encouraging atmosphere (elements of a safe learning environment) are prerequisites for a Classroom Culture of Conditionality (see Section 2.5.2) or what Ritchhart and Perkins (2000) refer to as a *mindful* classroom. In short, the findings make clear that uncertain and multi-dimensional topics in combination with the teacher asking questions of conditionality can provide opportunities for the development of uncertainty competences such as being able to entertain an enquiring mind and being able to reason (Tauritz, 2016).

5. Teacher asks about a child's strategy for finding information

The 5th category of questions of conditionality consists of questions the teacher asks about the child's strategy for finding and evaluating information, as well as assessing the trustworthiness of knowledge sources. The importance of these abilities is recognised by many scholars (Bråten, Strømsø & Salmerón, 2011; Ennis, 1985; Hobbs, 2017; Paul, 1995, Tauritz, 2016). During the first lesson, the teacher in Classroom C asks the children about their strategy for finding information and how they can find out whether the statement that 'wind turbines are the most effective way to produce energy' is true.

Teacher *... So, you think lots of people might have said it? How do you know it is true? We don't know. That's it. So how could you find out if it was true or not?*

Child *Collect opinions ...*

Teacher *Collect opinions from different people. Could you read the newspapers and see if you can find information in a newspaper maybe? Dannie, where else might you find out? Who could you ask?*

Dan *Mum and Dad ...*

Teacher *You could ask your Mum and Dad. Okay*.

The teacher asks conditional questions which can facilitate the development of uncertainty competences, such as being able to entertain an enquiring mind, being able to find, evaluate and utilise information, and being able to formulate a plan of action to deal with uncertainty (Tauritz, 2016). Rephrasing questions related to the search for information and making them conditional enhances their potential to stimulate divergent thinking. According to Davenport and Pagnini (2016), divergent thinking refers to the generation of "a variety of solutions, rather than converging on one correct answer" (p. 3) and the creation of new categories for structuring perception, rather than depending on previously established categories (Langer, 1992). Chanowitz and Langer (1981) suggest that considering information critically can also prevent "premature cognitive commitment" (p. 1052) to the unconditional truth of information (see Section 2.2.6).

Something else this excerpt demonstrates is how easy it is to fall back on our tendency to steer children in the right direction. First the teacher asks *How could you find out if it was true or not?* This is a conditional question (compare with a more unconditional version *How are you going to find out?*). One of the children promptly answers *Collect opinions ...* to which the teacher responds with a steering question, albeit infused with conditional vocabulary *Could you…maybe? Could you ask?* This pushed the child to consider newspapers as a source. As Langer and her colleagues (1989) say, it is not so easy to use questions of conditionality consistently, as we are so used to a more unconditional approach in teaching. It seems that a mixture of conditional and unconditional language might more accurately describe a natural way of speaking. See Section 10.6 for suggestions for further research.

The teacher in Classroom C reminded the children that they should remain critical of information, even if shared by several sources, or if obtained directly from a trusted source such as their teacher.

Teacher … *some people make statements and they say them in such a way that they sound like they are true. You're convinced by the fact that is true. Like birds flying into wind turbines and getting killed. Now if your teacher tells you that, you might go home and say Ms Daniels said such and such a thing. But just because I said it doesn't mean it is true.*

The children seemed to be a bit surprised by their teacher's remarks. However, instead of deepening the discussion about the credibility of information sources, the teacher quickly moved on. Earlier in that lesson the teacher had asked the children *Who would believe somebody just because they were a scientist?* The children gave mixed responses. *No. No! Yeah!* Probably only an experienced and confident teacher can say that she should not be blindly followed as a knowledge authority without losing her credibility. It is an important issue: how can such a statement be made in a way that facilitates the development of critical, independent thought, without creating a too extreme distrust of knowledge authorities and rejection of evidence-based knowledge? A mixture of uncertainty competences seems necessary as a counterbalance. The importance of the ability to judge the credibility and cognitive authority of information sources and the ability to respond in accordance with the underlying probabilities are obvious. Others include the ability to find, evaluate and utilise information (specific knowledge), the ability to reason, and the ability to interpret what others are communicating about their degree of certainty★.

Important and clearly related to this issue is the uncertainty competence **being able to conduct research on complex and uncertain topics★**. This new competence emerged during the observation in Classroom C where the children were conducting research into the topic of the dying of the sun, albeit in an elementary way. They formulated research questions, searched for information on internet, assessed the credibility of the websites and evaluated information as to whether or not it answered their question. Doing research had initially been included in the competence being able to find information, but it became evident during this observation that doing research is a distinct way of reducing uncertainty and should be given a separate entry in the list of uncertainty competences. This corresponds with the views of various scholars (Butler, 1978; De Haan, 2010; Wiek et al., 2015) who recognise the ability to conduct research as an important competence for finding answers to complex questions.

Uncertainty-based Questions of Conditionality

6. Teacher asks child about the certainty of information

Type 6 questions consist of questions the teacher asks about the certainty of knowledge. In Section 7.2 I presented an excerpt that shows how a speaker can use multiple linguistic devices to convey a particular degree of certainty. The teacher in that example makes use of these same devices while asking questions of conditionality. During the described teacher-child interchange, the teacher asks Kathy about her beliefs regarding the issue of birds being killed by flying into wind turbines. The teacher asks questions about how certain Kathy is about this issue and on what sources she is basing her assumptions. Later during that same lesson, the Classroom C teacher addressed all the children in a classroom discussion about their beliefs concerning the wind turbine issue and whether this could be a made-up story.

Teacher *Who <u>thinks</u> that is true? Hands if you <u>think</u> that is true! Hands if you <u>think</u> it is not true! Hands if you <u>don't know</u>. Most of us don't know. It is maybe one of those things that people have said, and you have heard it a few times and because you have heard a few times you begin to <u>think</u> it is true. But maybe it is not true…*

With her questions the teacher encourages the children to critically think about the information they consume. Often information is accepted as a given. In the example about the wind turbines the uncertainty is of a kind that can be reduced by finding reliable sources providing an evidence-based answer to the question if birds die because of flying into wind turbines. There are many types of uncertainty however (see Section 2.2.1), and as Jordan and McDaniel (2014a) explain, not all of them can be resolved by finding the *right* information.

Another aspect of the teacher asking questions about the certainty of knowledge is the very fact that the teacher is modelling asking those kinds of questions. It was noticeable that the children themselves in Classroom C asked the most questions about the certainty of knowledge in comparison to the other classrooms in this study. While some scholars see questions asked by the teacher as devices of power and control (Dillon, 2004), it seems clear from my observations that they can also be employed to encourage children to ask questions themselves and take an active part in the learning process. During the 1st lesson in Classroom C, the teacher and the children were talking about renewable energy sources.

Teacher	*…<u>at some point the sun will run out</u> and the wind doesn't always blow…*
Kate	*<u>How does anyone know this for sure, though?</u>*
Teacher	*How does anyone know what for sure?*
Kate	*That the sun will end up [dying].*
Teacher	*Because <u>scientists</u> <u>investigate</u> these things and have looked at what has happened to the sun over the last how <u>many years</u> they have been <u>studying</u> it. And <u>they can predict</u>, <u>but nobody does really know for sure</u>.*

At first the teacher says that she is certain about the death of the sun as this knowledge was produced by scientists investigating and studying the issue for many years. In other words, she bases her claim on trustworthy knowledge sources. Interestingly, the teacher then weakens the statement, by invoking mental phrases like 'predict' and 'nobody knows for sure'. I suggest that employing the language of conditionality constitutes a nuanced balancing act, which the teacher models during her lessons. Slowly views on being able to know with accuracy what is going to happen and predict the future are changing, moving towards a view that the world is a complex system that is characterised by a dynamic and creative unfolding of events. I agree with authors such as Jordan and McDaniel (2014a) and Barnett (2012) that the purpose of education is to help children to develop the competences needed to successfully navigate a world that is rapidly changing and is, in part, fundamentally unknowable. The literature is not clear, however, on how we can teach someone how to accept not knowing what will happen or what the right answer/action is, while remaining active and willing to engage with uncertainty. Perhaps children can learn best from observing teachers, such as Classroom Teacher C, who demonstrated that she is comfortable with not-knowing with her matter-of-fact attitude towards dealing with uncertainty.

Asking questions and talking about the certainty of knowledge with the children provides them with the opportunity to develop their own ideas as well as the language to be able to talk about uncertain issues. It also facilitates developing uncertainty competences such as: being able to accept not knowing (what will happen or what the right answer/action is), being able to find, evaluate and utilise information, being able to judge the credibility and cognitive authority of information sources and being able to respond in accordance with the underlying probabilities (Tauritz, 2016).

7. Teacher asks child about feelings regarding not knowing (what will happen/what the right answer or action is)

Questions about the certainty of knowledge are not only focused on the development of cognitive abilities. They also offer the teacher the chance to talk to the children about how they feel about knowing, not knowing or any degree of knowing in between. None of the teachers in this study talked to the children about their emotions in response to the lessons. During the focus group discussions children from Classroom B shared that they worried about the decisions they had to make during the debate about building dams. And some of the children from Classroom D shared in the focus group that they wondered if the teacher had been correct when he told the children that there were no beavers in Scotland other than the ones that had been released as part of the Beaver Trial. Some of those children went online after they got home from school to check if the information the teacher gave them had been correct. The teachers did not to talk to the children about these feelings. In doing so, they may have missed opportunities to explore the competence being able to accept not knowing (what will happen or what the right answer/action is). In addition, they could have discussed dealing with these feelings by searching for information that could increase their degree of certainty. Many topics dealt with in the classroom are not perceived by children as particularly personal or immediate, which might explain why few children displayed strong emotions during the classroom observations. Yet at the same time none of the teachers in my study asked the children how they felt during or after the lessons, apparently assuming that the children were unconcerned. Clearly, more was going on in Classroom B as the following excerpt shows.

Ben	*I thought at the start that it was quite a clear argument for your own, but then when you heard the other facts about the other you … kind of steer away*.
Researcher	*So when you felt a bit confused about what was right and what was wrong, or what was more valid, more important or less. How did that make you feel?*
Rory	*Really confused because there was less for-arguments but they were all really, really good arguments. But then there were more bad ones. So it was really hard to decide*.
Carol	*It felt really like… stuck for choice. Cause there's so good reasons for each one. So you are stuck in a position really, trying to pick. I still don't even really know what to pick.*
Researcher	*And did it make you feel just confused or was there something else?*
Bob	*I think it felt... Well after thinking about it a couple of days after. I think after I put the yes, I think there I was a bit regretful actually because I thought that the no actually had a bit more good arguments to go towards*.

This excerpt reveals that some of the children in Classroom B were emotionally affected by the lesson and the uncertainty that it generated. Careful topic selection is merited, as complex and uncertain topics without one clear solution, can potentially invoke emotions in the children that may not be overtly or immediately displayed but need to be addressed by the teacher. A concluding talk addressing the issue of uncertainty directly might elicit the sort of reactions that surfaced during the focus group interviews (see Section 4.4).

8. Teacher asks child how to solve a problem

The eighth group of questions are questions the teacher asks the child about useful procedures and methods for problem-solving. Orlich et al. (2013) defines problem-solving as “an inquiry learning process in which students seek answers to a question relevant to themselves and their culture” (p. 292). They continue by describing the teacher’s role as facilitating the children in defining the issue at stake, deciding how to obtain the required information, and testing and evaluating their findings. I will focus on the two problem-solving strategies that were evident in my study: *activating prior knowledge and experiences* and *thinking outside the box* (see Section 4.5 Learning activities).

The Classroom A teacher used conditional language when she asked the children to think of environmental issues that are harming our planet. The children compiled their ideas in small groups without researching the topic. For teams it is key to acquire an overview of the knowledge and experience the individual group members already have on a particular subject and to capitalise on that. Problem-solving can be enhanced by unhindered exploration of the issue that needs to be tackled. The children mentioned multiple environmental issues, suggesting that they did not feel they were being asked for one correct answer. Some of the issues the children mentioned were: *global warming, deforestation, poaching, catching too much fish, pollution, the number of people and running out of space*. After this the children were asked to sort the issues from least important to most important. The teacher acknowledged to the children that the exercise was *a challenge because they are all pretty important*. The teacher explained to the researcher that the aim of the exercise was less about a comparative analysis and more about generating dialogue and creative problem-solving, as the environmental issues are not equivalent and comparable.

Teacher	*... I want you to say what you have put at number one* [most important] *and tell me why you have decided that it is the most important issue?*
Anton	*Our must important was ‘oil spillages’.*
Teacher	*Oil spillages. Okay, can you tell me why?*

Anton *If the oil is spilled in the sea, then the fish can't get the oxygen particles from the water so they can't breathe and they suffocate. And sometimes they like ... die*.

One girl felt such urgency that she started thinking about solutions even before the teacher asked the children to do this: *Because ... we are running out of fossil fuels so we have to find different ways to make energy*. Eventually, the teacher did ask the children what they could do to try and solve some of the problems. One of the groups of children in Classroom A came with many solutions as portrayed in the next excerpt. Suggesting again, as Langer (2014) notes, that the conditionally phrased question gave them the sense they could explore freely.

Teacher *I want you to think about what we could do to try and solve some of those problems. What could we do? What kind of ideas do you have about what we could do? So share your post-it, post-it notes out. And talk to your group and see if you can come up with some suggestions.*

Child *We could use some more renewable ways to get energy*.

Child *Plant trees, plant …*

Child *… using animal waste to make petrol*.

Child *Put rubbish in bins, yeah!*

Child *Why don't we just … bury it in the ground?*

Child *Recycle! Recycle!*

Child *What else could we do?*

Child *Stop poaching*.

Child *Let's look at these and then see what we can do to stop them.*

Child *Okay. Running out of cocoa beans*.

Child *Stop eating chocolate! NO!*

Child *We could think how pollution is caused... by littering*.

Child *We could create biodegradable bags and rubbish*.

Child	*That is a quite good idea*.
Child	*What is pollution caused by though?*
Child	*Pollution is caused by oil and ships*. *Like oil tanks*.
Child	*We could do extra strong oil tanks*
Child	*But that will cost more money...*
Child	*It would mean we have economy dips.*
Child	*it would mean we have to pay more tax as well*.
Child	*Solar panel cars have like solar panel roofs*.
Teacher	*Okay, so work on environmentally friendly transport. Okay. Good ideas! Brilliant*.
Child	*Solar panels*.
Teacher	*Solar panels, yeah. Okay, so solar energy. Use more solar, environmentally friendly energy.*
Teacher	*Drive electric cars, brilliant! What else? What else could we do?*
Child	*Uh, walk?*
Teacher	*Walk more, yes! Leave the car at home*.

An important uncertainty competence is the ability to prioritise among urgent issues (Tauritz, 2016). This involves communicating about the issues and the certainty of gathered information, developing strong arguments, negotiating about the values involved, and making decisions. The children generated many solutions. See Section 10.3 for a more comprehensive discussion of the implications for practice.

Group 8 questions also involve teachers asking questions regarding previous experience. During the third observed lesson in Classroom C the teacher initiated a classroom discussion asking the class what would happen to humanity if the sun died. The teacher challenged them to think about what we know about human dependence on energy and the various energy sources we use, as well as considering a novel situation in which there wouldn't be a sun any more. The children were using their prior knowledge and experiences to answer her question. This process can be referred to as *transfer of knowledge*. Central to the process of transfer is learning how to apply previously gained knowledge in new situations (Alexander & Murphy, 1999; Orlich et al., 2013).

Teacher	*And solar panels. What again, if there is no sun than how do we do that? So if we've got the sun we can produce energy by using solar power, but if the sun dies out and there is no sun then how are we going to survive?*
Child	*Does the moon have energy?*
Teacher	*Does the moon have energy in the same way that the sun does?*
Child	*Yeah. Like, could you do a moon panel?*
Teacher	*A moon panel. That is an interesting idea. Where does moonlight come from? How does moonlight get to us? Dan can you explain that?*
Dan	*The sun shines on the moon to give it light to us.*
Teacher	*Just like a reflection isn't it? The sunlight hits the moon and is reflected off the moon and we see it. So, could you make energy from moonlight?*
Child	*No, because there wouldn't be any light.*
Teacher	*Would it be powerful enough? When you go out in the sun, you know you are out in the sun. How do you know you are out in the sun? Like yesterday.*
Child	*Because you get sun burned.*
Teacher	*You get sun burn, you get warm and hot. When you go out in the moonlight does that happen?*
Children	*No!*
Teacher	*No, it is much weaker isn't it? It is just enough to see by and if you are out in the dark and there are no street lights moonlight might give you enough light that you see where you are going. Would it be enough to produce energy? I don't know.*

Although, the teacher's question could have been asked in more conditional language (How might we survive if the sun dies out and we could no longer make use of solar power?) some of the children were motivated to come with creative answers. One of the boys transfers his knowledge of solar panels in a situation where there is a sun, to a situation without a sun. He asks if we could use moon panels instead. The teacher responds enthusiastically to his idea and supports his learning by asking a series of questions about moon light. This helps him to realise that the light from the moon is not strong enough to provide us with energy.

Alexander and Murphy (1999) discuss how transfer of what is learned takes place far less frequently than educators think. According to them, transfer generally requires high competence from learners as well as their engagement "in meaningful problem-based activities for which the knowledge and skills acquired are means for accomplishment rather than ends in themselves" (p. 563). In addition, they suggest that transfer requires a teaching process that is developed with the intention of transferring knowledge to other situations and domains. It takes among other things: time, practice, attention for problem-solving methods, explicit instruction and reflection by students and teachers on the transfer process. The teacher from Classroom C, however, did not emphasise and reflect with the class on the boy's efforts to transfer his knowledge. If she had, she could have engaged in a metacognitive dialogue with the children about employing prior knowledge and previous experiences as a tool for problem-solving. *Metacognition* in critical thinking refers amongst other things to having and becoming consciously aware of the representations of our thinking, our beliefs, our certainty of knowledge, and our reasoning process (Ellerton, 2015). Metacognitive thinking can facilitate the development of uncertainty competences, such as the ability to reflect on and (potentially) change one's beliefs regarding the certainty of knowledge, the ability to reason, and the ability to employ previous experiences. To develop metacognitive thinking children will, according to Dawson (2000) and Mulnix (2012), need a lot of guided repetition in thinking about their thinking. A question about metacognition related to problem-solving could be: 'How did you find solutions in the past?' and phrased more conditionally: 'How might you have found solutions in the past?' The tone of the first question seems, without literally saying it, to ask how successful solutions were found in the past. The second version, subtly different, seems a more open invitation to think out loud about solutions, not necessarily successful, in the past.

Another problem-solving strategy I observed in this study was *thinking outside the box*. This relates especially to uncertainty competences in the category *Learning to cherish uncertainty* (see Section 2.5). Central to thinking outside the box are the uncertainty competences: the ability to use uncertainty as a catalyst for creative action, the ability to entertain an enquiring mind, and the ability to employ lateral thinking. During the second lesson in Classroom C the teacher discusses with the children what the implications would be for life on earth if there was no sun. She keeps encouraging the children to think about creative solutions.

Teacher	*Do you think we would be able to find a way?*
Child	*Yeah*
Teacher	*What would be the way then?*
Child	*... build something in space, that shines down on the earth...*
Teacher	*That is an interesting idea. You could make something in space that is going to shine down on the earth. So, do you think some sort of machine or something?*

In the following excerpt the teacher seems to be asking the children to express their perspectives on the ability of humankind to come with a solution.

Child	*We would find a way.*
Teacher	*We would find a way?*
Child	*No scientists.*
Teacher	*Scientists would find a way? Scientists, I am not sure they are that clever.*

The teacher is encouraging the idea that it is possible to find a solution, but with a lot of effort, as *even* the scientist might not be clever enough. An inviting question the teacher could have asked would be: ‘Can you think of something nobody has thought of?' In conclusion, methods for problem-solving include: activating prior knowledge and problem-solving experiences and thinking outside the box.

8.4 Children's questions and answers and the teacher's response

Even though asking good questions is very important for learning, what is done with the response of the child, either by a peer or by the teacher, can be just as important (Alexander, 2006). An excerpt from Classroom A reveals an unexpected response from a child that could have led the teacher to ask questions of conditionality. The teacher asked an unconditionally phrased question about the changing weather patterns we are experiencing. Either a 'yes' or 'no' response was clearly anticipated. However, one child responded more creatively than expected in reply to such a question (see Section 5.2.2).

Teacher	*Has anybody been hearing in the news about different weather and ... Have you noticed that there is an awful lot more news about weather?*
Child	*Yes. Carlisle was flooded*.
Child	*Is it El Niño that is causing...?*
Teacher	*El Niño?*
Child	*Is that when the Pacific warms up and it sends bad weather?*
Teacher	*It affects the weather, doesn't it? Yep. Okay*.

The teacher probably didn't expect one of the children to mention El Nino as a possible culprit regarding the change in weather patterns! She seems unsure of how to react to it. (From the rest of the lesson it became apparent that the teacher wanted to link the change in weather patterns to CO_2-levels.) Perhaps, if the teacher did not know the answer to the child's question, she could have shared this and suggested that it was an interesting topic for them to explore. In this case the answer to her original question would not have been the end point as is, according to Beghetto (2016), the common approach in education. Instead he suggests an alternative in which the child's question becomes the starting point for personally relevant leaning from the child's perspective. The teacher might have embraced the uncertainty of not knowing instead of seeming to move away from an uncomfortable situation. With the following or similar conditionally phrased questions she could have facilitated the development of the children's reasoning abilities: What could El Niño be? And could this be one of the causes in the change in weather patterns that we are seeing around the world? Orlich et al. (2013) also share that encouraging the children to ask questions themselves can stimulate classroom interactions and the development of reasoning and communication skills.

Dillon (2004) is adamant that questions asked by children rather than by teachers are the start of effective learning. He explains that those "questions arise in ignorance and perplexity, stimulating the student's thought and empowering his action in an energetic pursuit of inquiry coming to terms in an answer" (p. 7). The following example shows how effective they can be. During the second lesson the Classroom C teacher talked with the children about life on earth if the sun died. Kate was struck by the idea that humans might not survive if there was no sun.

Kate	*Well could we still live even if we don't have a sun?*
Teacher	*Could we though? Could we live if there was no sun?*

The teacher repeated her question, acknowledging what Kate just asked, but without providing her with an answer. Both child and teacher are employing conditional language as they use the modal verb 'could' and a conditional to express their uncertainty regarding the possibility to live without the energy from the sun. The teacher's response encourages Kate to consider the implications and consequences of the death of the sun. The children discuss for a long time what might happen to humanity in such an event. It is a speculative question. The openness of the question, the conditional language being used and the teacher refraining from answering Kate's question appear to stimulate creativity. The children have been given the opportunity to develop uncertainty competences such as: the ability to use uncertainty as a catalyst for creative action, the ability to entertain an enquiring mind and the ability to reason (Tauritz, 2016).

It is interesting to examine the children's questions and answers as they prepared a presentation of their research topic (death of the sun). Although, some children in classroom C questioned how researchers can know when the sun will die and the teacher emphasised the uncertainty involved, children used a mix of unconditional and conditional language while making their PowerPoint presentations. See Figure 8.2 for an exemplary slide from one presentation titled: *How will the sun die?* The title is written in absolute terms even though this group in fact used conditional language in the body of their presentation: ... *scientists believe that that our sun only has five billion years left...*

Figure 8.2: Children used conditional language while presenting findings of their research topic

At the end of the presentation the children returned to their original question and presented the rest of the class with a quiz (see Figure 8.3 below) constructed using absolute categories, even though the topic provided sufficient opportunities for more open-ended questions. It should be noted that the children in Classroom C were used to these kinds of multiple-choice questions employed at the end of lessons to assess what they had learned. Children are standardly asked to tell what they know about a subject prior to lessons or to recapitulate what they know at the end of a lesson. This kind of questioning is a simple check for information retention. As Dillon (2004) states, the answers to these questions are either correct or incorrect and, more importantly, predetermined. There is one right answer independent of which child is answering. Such questions do not reveal whether or not concepts and processes are really understood and if children would be able to transfer their newly acquired knowledge to novel contexts. Still they are common in the classroom and the children clearly copied them in their quiz.

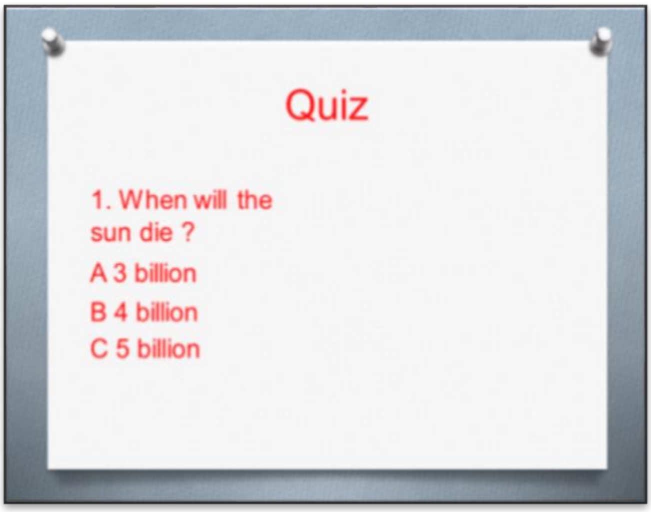

Figure 8.3: Children used multiple-choice questions at the end of their presentation

The data indicates that if teachers want to encourage children to ask more questions of conditionality in the classroom it could be worthwhile to pay attention to the types of questions they are modelling in their daily practice.

8.5 Summary

In Chapter 8 I introduced the concept of Questions of Conditionality, questions that (1) don't ask for one (or more) correct and pre-established answer(s), (2) are deliberately phrased conditionally to invite exploration, and (3) encourage learners to consider a multitude of perspectives before answering. Furthermore, these questions display several characteristics which make them inherently suited to the development of uncertainty competences: divergent, open-ended, exploratory, encouraging, stimulate creativity and innovation, and acknowledge multiple valid viewpoints.

A typology of eight categories of questions of conditionality emerged from the analysis of the transcripts alongside a review of the literature on classroom questioning. The categories are divided into two groups. The first group consists of five types of Socratic-based questions and is primarily focused on discovering what is known. All these question types are important for the facilitation of critical thinking, which is a significant component of uncertainty competences such as being able to reason inductively and deductively, being able to find, evaluate and utilise information, and being able to judge the credibility and cognitive authority of information sources (Tauritz, 2016). Furthermore, when conditionally phrased, these questions can become invitations for the children to offer more creative answers and look at topics from different perspectives without the risk that their answers will be considered *wrong* (see Section 5.2.2).

The second group consists of three types of uncertainty-based questions and is primarily focused on discovering what we don't know (yet) or cannot know for sure. Appendix 8.1 Typology of Questions of Conditionality provides an overview of the eight categories, including exemplary questions and the uncertainty competences which they address. The numbers in the table indicating the uncertainty competences correspond to the numbers in the Revised List of Uncertainty Competences in Section 10.7.

Chapter 9 Returning to the heart of the matter

> Perhaps those teachers … who knowingly ask their students complex and perplexing questions are doing them a service. Indeed, I would argue that they are educating their students to doubt, think critically, so consider issues from multiple perspectives, and to provide convincing arguments for their views.

Gordon (2006, p. 23)

9.1 Introduction

This study took an interpretive research approach that examined five Scottish case studies in-depth. During the data analysis it became evident that the specific pedagogical strategies employed by the teacher shapes to a great extent what will happen in the classroom. The findings indicate that these strategies comprise five key elements: learning objectives, topic, learning activities, teaching resources, and language and questions. Employment of the language of conditionality, which includes the vocabulary, grammar and questions of conditionality, became an unanticipated focus of attention (see Section 6.1). The teachers had been asked to select a complex sustainability topic that included a confrontation with contradictory information. They were then free to choose all other aspects of their teaching strategy. I provided them with minimal guidelines, as I wanted to study what they themselves would elect to do. In Chapters 4 to 8, I examine each of the key elements separately. In this Chapter, I view the findings from a different perspective. Instead of focusing in on the individual elements, I reflect on the complete teaching strategy on a classroom level, and, in particular, on the opportunities for developing uncertainty competences afforded by each strategy. Of these strategies some were deliberately selected by the teachers while others were employed without being part of a written lesson plan. A table summarizing the teaching strategy each of the five teachers employed can be found in Appendix L. The uncertainty competences that played a role in the classrooms refer to the revised list of uncertainty competences which is discussed in Section 10.7.

9.2 Teaching strategies employed per classroom

I will discuss each classroom briefly and where appropriate I refer to specific sections in the other findings chapters in order to make deeper theoretical connections between the observations and the development of the conceptual framework.

Teaching Strategy in Classroom A

The Classroom A teacher formulated *learning objectives* focused on acquiring knowledge about global warming and developing the children's ability to link global issues to local experiences (see Section 3.3.2). The selected *topic,* global warming, provides a rich array of opportunities for inviting uncertainty into the learning environment (see Section 4.4.3). Similarly, for example, Hauge and Barwell (2017) discuss how critical mathematics lessons about climate change connect students to diverse aspects of uncertainty, such as uncertainty related to the employment of models as representations of reality, irreducible uncertainty (uncertainty which cannot be completely eliminated), and coping with uncertainty.

The selected *learning activities* in Classroom A consisted of small group discussions, classroom discussions and a presentation by the teacher, and provided a variety of opportunities for the children to develop uncertainty competences. In agreement with Cohen and Lotan (2014), I observed that working in small groups provided the children with the opportunity to develop skills needed to be able to work in teams with mixed knowledge, skills and experience as well as to be able to interpret what others are communicating about their degree of certainty★ and to be able to express one's own degree of certainty★ (see Section 4.5.2). Small group work also confronts the children with different points of view, and thus offers opportunities to develop their ability to be able to understand people with different perspectives.

One of the *teaching resources* Teacher A employed was a PowerPoint presentation about global warming. The slides contained some conditional language which provided learning opportunities for discussing how to interpret what others are communicating about their degree of certainty★ and, in general, the different ways in which people communicate about uncertainty (see Section 6.2.3). During the post-observation interview, the teacher explained that she had not been aware of this opportunity for exploring conditional language. Even though the teacher employed predominantly unconditional *language* in her interactions with the children, she did create significant learning opportunities by employing questions of conditionality at the beginning of the small group work. For example, she asked the children: *Which environmental challenges do you know about? How would you order them from least* *to most important? What kind of solutions can you come up with for those challenges?* (see Section 8.3). These questions have more than a single right answer and may invite a child to both consider a multitude of answers and perspectives before answering (Paul, 1995), and encourage a creative response to the initial questions (Langer, 2014). This kind of questioning provided the children with opportunities for creative exploration of what they collaboratively knew in their group. Examples of specific uncertainty competences that may be developed include the ability to entertain an enquiring mind and the ability to use uncertainty as a catalyst for creative action (Tauritz, 2016).

From the findings it could be observed that the children were developing uncertainty competences, even though uncertainty competence development was not deliberately formulated as a learning objective. The key elements of the selected strategy that seemed to produce the most opportunities for uncertainty competence development include the complex topic of global warming, the learning activities in the form of small group work, and the use of conditionally phrased questions when giving the instructions for the small group work.

Teaching Strategy in Classroom B

The teacher in Classroom B formulated three learning objectives for her students: to acquire knowledge of dams and their purpose, to know some of the advantages and disadvantages of dams, and to be able to hold a debate about building dams (see Section 3.3.2). The first two objectives focused on content knowledge, although the second objective did create learning opportunities for developing the language needed to communicate about the advantages and disadvantages of dams and debating skills. The third objective focused on skill development and created opportunities for the development of such uncertainty competences as the ability to reason (Tauritz, 2016) and the ability to express one’s own degree of certainty★. The complex topic of building dams and the multitude of actor groups that may be affected by dams, such as citizens whose land will be flooded, hydroelectric companies, and government and environmental organisations, provided diverse opportunities for uncertainty competence development. Examples are, being able to understand people with different perspectives and being able to respond in accordance with the underlying probabilities.

The lesson commenced with a classroom discussion about dams, followed by additional learning activities including some small group work, note taking and designing of posters. During the rest of the lesson the children debated about dams. Debating in itself is often employed as a learning activity; in this study two out of five teachers selected it. Healey (2012) reminds us, in agreement with many educators, that debates offer opportunities for enhancing communication, research, critical thinking, argumentation and persuasion skills. The debate in Classroom B, in accordance with this appraisal, provided the children with opportunities for the development of many related uncertainty competences including: being able to find, evaluate and utilise information, being able to reason, being able to respond in accordance with the underlying probabilities, and being able to understand people with different perspectives. Further, it seems unarguable that debaters need to be able interpret what others are communicating about their degree of certainty★ and to able to express their own degree of certainty★. Even though the children had learned about debating and should have been expecting counter-arguments, the encounter with the other group's arguments seemed to create confusion similar to suddenly being confronted with another person's conflicting point of view in everyday life. The observations suggest that this variation on preparing for a debate, in which the argument *for* was prepared in one classroom and the argument *against* in another, was a particularly useful technique for engaging the children and developing uncertainty competences such as being able to understand people with different perspectives.

The children in the Classroom B focus group shared that they were still confused and uncertain - days after the debate - about their choice to be in favour or against dams (see Section 4.5.4). Even though the topic was relatively distant from their world, the lesson seemed to affect them emotionally. This, however, might have been linked to the fact that the lesson was part of a larger Storyline project (Bell et al., 2007) about dams that the class had been working on for a few weeks. According to Letschert (2003), this educational approach offers creative ways to engage children in critical thinking, through co-creation of the story, characters developed by the children, and teacher-orchestrated critical incidents. The engagement with the lives of self-created characters seemed in this case, as evidenced by the comments made during the focus group interviews, to have resulted in the children identifying with the characters and bringing their concerns regarding the new dam into a more personal and immediate perspective. By developing this learning activity format with her colleague, the Classroom Teacher B had created an opportunity to discuss the children's feelings of confusion when confronted with the arguments of the opposing group. Perhaps if the teacher had been familiar with uncertainty competences, she would have used the opportunity to explore uncertainty competences such as being able to accept not knowing (what will happen or what the right answer/action is) or being able to reflect on and (potentially) change one's beliefs regarding uncertainty (Tauritz, 2016) with the children.

The key elements from the selected strategy that seemed to produce the most opportunities for uncertainty competence development in Classroom B include the controversial topic of dams and the lesson objectives that led to the development of language for discussing advantages and disadvantages, multiple perspectives and debating. The learning activities played a role as well; in particular, the format of the debate preparation, invited uncertainty and feelings of confusion into the learning environment, created a chance to develop uncertainty competences, including being able to accept not knowing (what will happen or what the right answer/action is) (Tauritz, 2016). The development of this competence could have been further enhanced if the teacher had explored these feelings and ideas with the children.

Teaching Strategy in Classroom C

The *learning objectives* that the Classroom C teacher formulated were to be able to discuss the principal ideas behind the complex scientific issue of renewable energy, to be able to participate in group discussions and to be able to back up opinions with scientific evidence (see Section 3.3.2). These objectives created opportunities to develop, amongst others, uncertainty competences related to being able to interpret what others are communicating about their degree of certainty★ and being able to express one's own degree of certainty★, the ability to work in teams with mixed knowledge, skills and experience and being able to reason and use evidence to support one's argument (Tauritz, 2016). The teacher began the first of the three observed lessons with the *topic* of renewable energy (wind energy), but introduced two other topics for the second and third lesson based on two themes that emerged during the classroom discussion: 'when will the sun die?' and 'what do birds do for the world?' (see Section 4.4.3). In responding to the children's emergent questions in this way, the teacher nurtured the children's curiosity (Starko, 2010) and encouraged the development of the uncertainty competence to be able to entertain an enquiring mind (Tauritz, 2016).

The *learning activities* remained more or less the same, despite the topic change, and consisted of classroom discussions and conducting research in small groups, after which each group prepared a PowerPoint and presented its findings to the rest of the class (see Section 4.5). Teacher C was the only teacher in this study who selected conducting research in small groups. Observations in the classroom suggested that it was a useful strategy that created many opportunities for developing uncertainty competences. Examples of such uncertainty competences are the ability to find, evaluate and utilise information, the ability to judge the credibility of knowledge sources and the ability to reason (Tauritz, 2016), as well as the ability to conduct research on complex and uncertain topics★. See Section 8.3 (Question type 5) and Section 10.7.

The teacher employed a variety of *teaching resources*, such as information sheets and work sheets with propositions she had compiled, a book and the Internet. Although, the children did use the book the teacher gave them about the solar system, they more often went online to find information. Something interesting happened when the children from the different groups presented their answers to the same research questions. The children responded with some surprise to the fact that the answers were not always the same. It spurred a discussion about knowledge sources and the question: How can you know which source to believe? It also led to discussion of an unexpected, related topic, namely, referencing sources.

During the classroom discussions, the teacher supported the children in developing the *language of conditionality* pertinent to talking about controversial topics, the certainty of knowledge and multiple perspectives (see Section 5.2.1). In addition, the teacher asked many *questions* and encouraged the children to do the same. She also stimulated them to be critical of knowledge sources – even if that source was their own teacher. Intriguingly, the development of vocabulary of conditionality, asking many questions and being critical of knowledge sources happened without being mentioned specifically in the learning objectives.

The key elements from the selected strategy that seemed to produce the most opportunities for uncertainty competence development in Classroom C were: the emergent and complex topic about the dying of the sun, the learning objectives that included the ability to discuss complex scientific issues, being able to communicate well within a team and the ability to back opinions up with scientific evidence. Other key elements in this classroom were the learning activities, in particular, the classroom discussions, the inquiry-based learning activities and the resulting presentations which afforded the exchange of differing answers to similar research questions, and the development of language of conditionality.

Teaching Strategy in Classroom D

In Classroom D, the teacher formulated the following *learning objectives*: to be able to use print and online sources to understand a controversial topic, to be able to use the information to back or refute arguments, and to develop skills in listening and persuasive language. Although not specifically mentioned in the lesson plan, the teacher clearly also set out to teach the children about beavers and ecology (see Section 3.3.2). The chosen objectives provided opportunities for the development of uncertainty competences, such as being able to reason, being able to respond in accordance with the underlying probabilities (Tauritz, 2016), being able to interpret what others are communicating about a controversial topic and their degree of certainty★, as well as being able to express one's own degree of certainty★. The controversial *topic* of beaver reintroduction in Scotland offered many opportunities for the development of uncertainty competences, principally due to the many actor groups and hence many perspectives involved (see Section 4.4.3). The development of competences such as the ability to understand people with different perspectives and the ability to find and utilise information (Tauritz, 2016) were encouraged by this choice.

The *learning activities* included a classroom discussion about beaver ecology, small group work, and a parliamentary debate, which provided a variety of opportunities for developing uncertainty competences such as the ability to understand people with other perspectives and the ability to reason (Tauritz, 2016) (see Section 4.5.1; 4.5.2 and 4.5.4). The teacher started with a classroom discussion which activated the prior knowledge of the children (Harris & Rooks, 2010; Mason, 1996) and at the same time identified gaps in the children's knowledge about beavers. During the discussion the teacher also reviewed with the children what they remembered from the lesson the previous day when they were introduced to doing parliamentary debates by means of debating the reintroduction of the wolf in Scotland. The children prepared for the debate in small groups, which involved working independently from the teacher and working and cooperating with group members – both of which Cohen and Lotan (2014) highlight as important characteristics of this learning activity; the learning activity is a key element of the teacher's strategy and contributed in Classroom D to developing the ability to work in teams with mixed knowledge, skills and experience (Tauritz, 2016).

Time constraints limited the teacher's capacity to teach this extra science lesson. It was therefore not feasible for the children to search for information sources themselves. As the children had never previously discussed this topic. The teacher felt compelled to provide the children with *teaching resources* (PowerPoint presentation, information sheets and websites) from the beaver trial to ensure that they had basic content knowledge about beavers. Some of the children were apparently surprised to hear during the classroom debate that there were no beavers in the wild in Scotland (see Section 4.5.4) and, although they appeared a bit confused, they did not seem to question the validity of the information sheets during the remainder of the lesson. During the focus group interview with the children from Classroom D, however, it became clear that several of the children had gone home that afternoon wondering about the classroom discussion, which prompted them to go online and read about the topic of beaver reintroduction in Scotland. These children demonstrated the development of the uncertainty competences to be able to entertain an enquiring mind, as well as the ability to critically question what the teacher told them: the ability to judge the credibility and cognitive authority of information sources (Tauritz, 2016) and what their own beliefs were about the presence of beavers in Scotland.

The Classroom D teacher used predominantly unconditional *language* and focused on developing language related to beaver reintroduction and ecology, multiple perspectives and debating. Unintentionally, the teacher instigated a discussion about the language he had been using to discuss the topic of beaver reintroduction. It stimulated the children to reflect on the way in which the teacher expressed his degree of certainty about beavers living in Scotland (see Section 6.3.2) and contributed to their ability to interpret what others communicate about their degree of certainty★.

In conclusion, the key elements that provided the most opportunities for uncertainty competence development in Classroom D were the learning objectives, the controversial topic of beaver reintroduction, the learning activities (including the small group work and the parliamentary debate), and the learning experience that was created by the teacher's language use regarding the presence of beavers in Scotland.

Teaching Strategy in Classroom E

Teacher E made a potentially interesting *topic choice*, namely, the process of pollination and plant reproduction, but was limited by outside factors (unrest in the classroom due to the approaching end of the school year for her P7 class) in utilising the topic to its full potential for uncertainty competence development. Her *learning objectives* focused on the ability to understand that many plants need animals and insects for pollination and the ability to describe the reproductive structure of a flower. The transfer of content knowledge predominated in the observed lesson. The Classroom E teacher selected several *learning activities*, which included a classroom discussion about the role of pollinators, reading information sheets and doing some accompanying exercises, as well as crafts. The latter involved designing flowers and integrating what the children had learned about plants' adaptations to pollinators. The *teaching resources* the teacher employed provided the children with some opportunities to develop the uncertainty competence being able to find, evaluate and utilise information (Tauritz, 2016). These resources were created by a third party and used predominantly unconditional language. The teacher focused on developing the *language* related to plant reproduction and pollination. This topic could have been transformed into a multidimensional real-world problem (Nilson, 2010; Paul, 1995) by including in the lesson plan such aspects of the topic as our dependency on pollinators for food production, the worldwide decline in pollinators, and the politics that are involved in this sustainability challenge. This could have afforded additional opportunities for uncertainty competence development.

9.3 Teaching strategies summarised

From the findings it would appear that none of these teachers employed a teaching strategy in which all five key elements: (1) learning objectives, (2) topic, (3) learning activities, (4) teaching resources, and (5) language and questions were optimally designed to invite uncertainty into the learning environment. However, in all classrooms there were some opportunities for facilitating uncertainty competence development (see Table 9.1).

Classroom	Number of different uncertainty competences that were potentially enhanced
A	7
B	8
C	12
D	7
E	1

Table 9.1: Number of uncertainty competences whose development was potentially enhanced through the selected teaching strategies in each classroom

The teaching strategy from Classroom C provided the most opportunities. While most of the topics the teachers chose in this study provided ample opportunities, the fact that the Classroom C children studied topics that emerged during the first observed lesson and were a direct result of questions they had asked was a significant factor. Although Teacher C's learning objectives were relevant, none were specifically phrased to include learning how to deal with uncertain and ambiguous knowledge. The learning activities that the teacher selected, especially the classroom discussions and the inquiry-based learning activities provided many opportunities for uncertainty competence development. Furthermore, I view the attention Teacher C paid to exploring the language needed to communicate about uncertain topics and multiple perspectives as an important contributing factor to the value of the teaching strategy she employed with respect to the development of uncertainty competences.

9.4 From Conditional Instruction to Language of Conditionality-richness

One of the characteristics of a learning environment conducive to teaching uncertainty competences is the employment of conditional instruction (see Section 2.5.2). As the analysis continued and the concept language of conditionality emerged, the way I viewed the learning environment underwent modification. The findings had revealed an important additional learning environment characteristic: *Language of Conditionality-richness*. Ellen Langer specifically studied the response from learners to written conditional instructions (Langer & Piper, 1987; Langer et al., 1989; Langer, 1993). In Chapter 6, 7 and 8, however, I demonstrated that the use of conditional language is more complex and involves a deeper understanding of what linguists call *epistemic modality* or *modal language* (Bassano et al., 1992; Coates, 1988; Wilcox, 1991). The language of conditionality encompasses those aspects of modal language that deal with the vocabulary and grammar necessary to communicate about the certainty of knowledge, probabilities and uncertainty. As when learning any other language a rich learning environment, in this case a language of conditionality-rich learning environment, immerses a learner in the language to be learned. Classroom Teachers B, C and D all employed a wide range of language relevant to the discussion of complex and uncertain topics. Classroom Teacher C in particular actively explored the language of conditionality with the children. This study strongly suggests that the more teachers employ the language of conditionality in their classrooms, the more the children are likely to learn and apply this way of communicating and concurrently demonstrate other classroom behaviours such as: critically questioning information, having a less rigid perspective, and responding more creatively to assignments (see Chapter 5).

Chapter 10 Synthesis

> The fears people may have of an educational system that creates a place for several perspectives [and uncertainty], is that nothing will remain stable, there will be nothing reliable on which they can lean for continuity. Yet we discover that by viewing the same information through several perspectives, we actually become more open to that information … If we fail to explore several perspectives, we risk confusing the stability of our own mindset with the stability of the phenomenon itself.
>
> (Langer, 1997, p. 133)

10.1 Introduction

In this final chapter, I consolidate what can be learned from this study regarding the strategies employed by the teachers I observed that develop the children's uncertainty competences, and the implications these may have for the practice of education. Section 10.2 discusses the answers to the research questions posed at the end of Chapter 2 and describes the three main contributions to knowledge that emerged from this study. This is followed in Section 10.3 by an outline of their implications for practice, especially with regard to teacher training. In Section 10.4 I make two recommendations for education policy. Section 10.5 adds a developmental perspective to the discussion of the findings regarding the use of modal language, the understanding of the concept of certainty/uncertainty, and the proficiency in the language used to communicate about it. This perspective reinforces my suggestion that the upper primary school years are suitable to developing the language to be able to talk about the certainty of knowledge. In Section 10.6, four suggestions are made for further research regarding this fascinating and enigmatic topic of teaching children how to manage knowledge uncertainty. In Section 10.7, I take a final look at changes that led to the Revised List of Uncertainty Competences.

10.2 Bringing it all together – Contributions to knowledge

Stake (1995) notes that generalising and making assertions on the basis of a relatively small database, such as my five case studies, depends upon the rigour and depth of the data verification methods (see Chapter 3). According to Schwartz-Shea and Yanow (2012) it also demands the responsibility of careful interpretation by the researcher. I have kept this in mind, while summarising my three contributions to knowledge. At the end of Chapter 2, I introduced the conceptual framework, and described the two major theoretical concepts that initially guided my work: (1) uncertainty competences (see Section 2.3) and a (2) learning environment conducive to the development of uncertainty competences (see Section 2.5). In its original design, my study focused on the characteristics of a learning environment that might support the development of uncertainty competences. It was impressed on me as the study progressed that the teacher does not have equal influence on the different key elements of the learning environment; for example, the teacher has limited influence regarding the physical setting (building, classroom, school grounds) and the cultural institutions in a specific country (see Section 2.5.1). As a result, I focused in on the teaching strategy because it was becoming clear that this was a key element of the learning environment that the teacher is able to influence. I later *zoomed in* even further on a particular key element of the teaching strategy: language and questions.

I presented two working research questions in Chapter 2. These questions evolved over the course of the research process. Notably, I did not know at the beginning of the research project that I would employ a format comprising five case studies. This required an appropriate revision of the research questions. These revised questions refer specifically to the five case studies:

1. Which teaching strategies did the teachers employ to teach about complex and uncertain sustainability challenges?

2. Which uncertainty competences were being taught by the teachers?

The findings indicate that the specific teaching strategies the teachers employed to teach about a complex sustainability topic involving contradictory information provided a considerable range of opportunities to develop uncertainty competences. The selected complex sustainability topics, varied learning activities such as classroom discussions, small group discussions, debates and inquiry-based learning and teaching resources containing a mixture of unconditional and conditional language each afforded particular opportunities (see Chapter 9). See Appendix L for a summary of the employed teaching strategies and the uncertainty competences that were being developed in each classroom.

In the remainder of this section, I concentrate on three main contributions to knowledge regarding the key elements of the teaching strategy for developing uncertainty competences. Early examination of the collected data indicated interesting differences between the teaching strategies employed by the five teachers and the opportunities these strategies afforded for uncertainty competence development (see Chapter 9). These data eventually developed into one of my major findings, the concept of Language of Conditionality and how it was employed in classroom interactions (see Chapter 6).

Langer's concept of conditional language was central to my thinking at the beginning of the data analysis phase (Langer, 1992, 2000, 2014, 2016). To recap, conditional language refers to stating that things could be true, rather than saying they are true (Langer et al., 1989). During the data analysis and explorations in the field of psycholinguistics four things became clear to me. First, I realised that with more knowledge of conditional language it is possible to communicate with more nuance about uncertainty (see Section 6.2) and avoid binary thinking (see Section 4.5.4). Second, that Langer's concept did not address how teachers might integrate conditional language, including specific vocabulary and relevant grammar into their classroom communication. Third, that it would be useful for children to actively learn how conditional language can be used to communicate about the certainty of knowledge (see Section 6.3.2). Fourth, I came to understand that questions can be phrased both unconditionally and conditionally, with the latter facilitating the development of particular uncertainty competences (see Chapter 8). These realisations led to the emergence of a new concept: Language of Conditionality (see Chapter 6).

Contribution to knowledge #1: The teacher's employment of language of conditionality in classroom interactions supports uncertainty competence development

Language of conditionality combines Langer's broadly defined concept of conditional language (Langer & Piper, 1987; Langer et al., 1989) with the more detailed aspects of modal language (Bassano et al., 1992; Coates, 1987; Wilcox, 1991) that deal with expressing degrees of certainty and possibility, employing a range of linguistic devices. Analysis of my findings led to the establishment of the concept of language of conditionality, consisting of three essential aspects: (1) Vocabulary of conditionality, (2) Grammar of conditionality, and (3) Questions of conditionality (see Section 6.1). Vocabulary of conditionality refers to the words needed to communicate clearly and with nuance about the certainty of knowledge, multiple perspectives and complexity. Grammar of conditionality refers to grammatical rules and linguistic devices that enable an individual to express a particular degree of certainty of knowledge in their written or oral communication (see Chapter 7). Simultaneously, the grammatical structures and words individuals employ provide listeners and readers with crucial information for understanding their messages. Different linguistic devices, such as modal auxiliary verbs, modal adverbs, mental verbs, evidentials (see Section 7.2) and conditionals (see Section 7.3) provide speakers with options for expressing their degree of certainty about knowledge in a more nuanced manner. Questions of conditionality refer to a variety of questions that invite uncertainty into the learning process (see Chapter 8). They, together with the teacher's employment of vocabulary and grammar of conditionality, hold the potential to facilitate the child's development of uncertainty competences.

The findings showed that, independent of the extent to which the teacher employed conditional language, the children used more unconditional than conditional language in all the observed classrooms. However, the findings showed something else as well. In the classroom where the teacher used a mixture of unconditional and conditional language, but with the emphasis on the latter, the children displayed different classroom behaviour and uncertainty competences than in the other four classrooms. In accordance with findings of Langer and colleagues (1989), my study found that those children more often entertained an enquiring mind, judged the credibility and cognitive authority of information sources, and employed uncertainty as a catalyst for creative action, which resulted in more creative answers than those of the children in the other observed classrooms. My findings also suggest that when teachers employ questions of conditionality other uncertainty competences may be developed as well, such as the ability to reflect on and (potentially) change one's beliefs regarding uncertainty and the ability to reason (Tauritz, 2016). Teachers can ask questions of conditionality to explore with children how certain information is, and whether they can reduce their uncertainty by finding (additional) reliable information or have to accept that there are circumstances in which uncertainty cannot be (entirely) resolved. Teachers can employ modal verbs to rephrase unconditional questions into more inviting conditional questions having more than one right answer.

Significantly, none of the primary school teachers in my study were familiar with the term conditional language and the potential effect its use could have on the children's use of language and their classroom behaviour. They were also unaware of their own use of conditional language or whether the teaching resources developed, either by themselves or by third parties, incorporated any conditional language. The study demonstrated, nonetheless, that when teachers employ a mixture of unconditional and conditional language a space is created for children to explore multiple perspectives, come with creative answers, and practice how to deal with uncertainty.

Contribution to knowledge #2: Children who are proficient in language of conditionality are able to communicate more clearly and with nuance about the certainty of knowledge

The second contribution to knowledge focuses on the importance of the children themselves becoming proficient in the use of language of conditionality. My findings suggest that being able to communicate about the certainty of knowledge requires acquiring relevant vocabulary and an understanding of grammatical structures that enable individuals to express themselves, as well as understand what others are communicating about uncertainty. In turn, the ability to use and understand the language of conditionality contributes significantly to the development of the majority of uncertainty competences as has been explicated throughout. Especially clear are the links to the two new uncertainty competences discussed below.

Two uncertainty competences which, though not explicated in the lesson plans as learning objectives, were being taught in some classrooms: the ability to interpret what others are communicating about their degree of certainty★ and the ability to express one's own degree of certainty★. These were two new uncertainty competences that emerged from the findings (see Section 6.3.2). Importantly, these competences help the learner make sense of what is being communicated about the certainty of knowledge in a particular situation. They are so basic to communication about complexity and uncertain knowledge that they are easily overlooked; however, they are essential and can be purposefully taught in the classroom (see 10.3).

In the third and final contribution to knowledge, the focus is on the key elements of a teaching strategy that supports the children's development of uncertainty competences. The fifth key element of the teaching strategy, language and questions, is intricately interwoven with the other four key elements (see Section 4.2).

Contribution to knowledge #3: There are four key elements, in addition to language and questions, of a teaching strategy conducive to uncertainty competence development: learning objectives, suitable topics, learning activities, and teaching resources

I suggest that, in addition to the language and questions discussed in the first two contributions, ample opportunities need to be provided for the development of children's uncertainty competences. The development of these competences can be benefited by the employment of carefully chosen learning objectives, suitable topics, learning activities and teaching resources.

Learning objectives

This study suggests that teachers need to be made aware of uncertainty competences and their relevance for preparing children for succeeding in a rapidly changing world. With this awareness the teacher can deliberately select uncertainty competences as learning objectives. When teachers were asked to teach about a complex sustainability topic, only some competences resembling uncertainty competences, especially ones that are comparable to critical thinking skills and can be found in the category 'Learning to reduce uncertainty', were mentioned as learning objectives. Although similar, it should be clear that they were not specifically operationalised with managing uncertain and ambiguous knowledge in mind.

Topics for uncertainty competence development

Suitable topics for developing uncertainty competences can be described in terms of compositions of varying degrees of uncertainty, multiple and incompatible perspectives and values, contradictory information, and decision-making regarding problems without obvious solutions. An important conclusion from this study is that multiple characteristics make topics particularly suitable for the development of both language of conditionality and uncertainty competences. According to various scholars (Hall, 2014; Morrison, 2008; Paul, 1995; Tauritz, 2016), it would be beneficial for teachers to learn how to distinguish between monological and multilogical problems. Problems that are multilogical/*inter-disciplinary* (1), boundary crossing (2) *complex*, (3) *uncertain* topics provide more opportunities for the development of uncertainty competences. Topics that are (4) *dynamic* (Voogt & Pareja Roblin, 2012), (5) *controversial*, (6) *confusing,* (7) *contain misinformation* (Higgins, 2009) or are even (8) *unknowable* (Barnes et al., 2008), make it difficult to fully understand the subject, thereby creating opportunities for uncertainty competence development. Topics that are (9) *emergent* (Jones, 2012), (10) *immediate* (Kotter, 2008) and (11) *personally relevant* (Prinski et al., 2018) are perhaps not particular to teaching uncertainty competences but are known to enhance student engagement and intrinsic motivation to learn, and can encourage the learner to engage with uncertain and complex topics. Sustainability challenges are promising topics for uncertainty competence development both because they urgently require solutions and because they can be distinguished by many of the characteristics indicated above (see Section 4.4).

Learning activities for uncertainty competences development

Teachers who want to develop particular uncertainty competences can select learning activities that provide the best opportunities for developing those competences. *Inquiry-based learning*, often already associated with managing uncertainty, has great potential for facilitating uncertainty competence development. It fosters being able to entertain an inquiring mind, being able to conduct research on complex and uncertain topics★, being able to formulate a plan of action to deal with uncertainty and being able to respond in accordance with the underlying probabilities (see Section 4.5).

Scholars hold differing views about the value of *classroom debates*, with some voicing concern that debates encourage binary rather than holistic thinking (Davies & Barnett, 2015; Langer, 2016), while others (Healey, 2012; Omelicheva & Avdeyeva, 2008;

Oros, 2007) emphasise that learners may put more intellectual effort in understanding complex issues, as well as listening carefully to their opponent's arguments and forming strong counterarguments. The classroom debates I observed displayed opportunities for the children to develop uncertainty competences such as their ability to reason (Tauritz, 2016), the ability to interpret what other are communicating about their degree of certainty★ and the ability to express one's degree of certainty★.

Another learning activity, *small group work*, could, when introduced by the teacher with specific questions of conditionality (e.g. Which issue <u>could</u> you best tackle first? <u>Could</u> this solution work? and What <u>could</u> your plan of action to solve this issue look like?), also create possibilities for the development of uncertainty competences. Examples are: the ability to prioritise among many urgent issues, the ability to formulate a plan of action to deal with uncertainty, and the ability to respond in accordance with the underlying probabilities (Tauritz, 2016).

Teaching resources for uncertainty competences development

Teaching resources comprise the materials and tools the teacher employs to support the children's learning process (see Section 4.6). Resources that, where appropriate, communicate that something can be true, rather than stating that it is certain to be true, acknowledge the existence of uncertainty and thereby have the potential to support the development of uncertainty competences such as the ability to interpret what others are communicating about their degree of certainty★. Teaching resources that include conflicting points of view could be essential in developing the children's understanding of complex problems that typically have no single right solution (Kreber, 2009), as well as uncertainty competences including being able to understand people with different perspectives and being able to find, evaluate and utilise information.

10.3 Implications for the practice of education

Implication for practice #1: uncertainty competence development and language of conditionality in teacher education

This study has important implications for in-service (and pre-service) teacher education. These concern the introduction of uncertainty competences and language of conditionality in teacher education programmes in order to familiarise teachers with these concepts. Teachers need to become more competent in their use of language of conditionality. However, if we wish children to use more language of conditionality themselves, it is apparent that the teacher's employment of this language is not sufficient in itself. It is necessary for the teacher to deliberately teach children about the language of conditionality and how to use it. Competence in the use of language of conditionality can also support the children's development of other uncertainty competences, such as being able to judge the credibility and cognitive authority of information sources and being able to respond in accordance with the underlying probabilities.

Teachers who are aware of the concepts of uncertainty competences and language of conditionality as well as their importance will be in a position to deliberately select (1) learning objectives focused on developing uncertainty competences and relevant vocabulary and grammar of conditionality, as well as selecting (2) appropriate topics, (3) learning activities and (4) teaching resources. If all 20 uncertainty competences (see Table 10.1) are to be taught in P6/P7, deliberate action would seem to be required to explicitly include them as learning objectives in lesson plans.

Teaching language of conditionality requires the teacher to create learning environments that afford children with many opportunities to come in contact with vocabulary and grammar related to the certainty of knowledge, multiple perspectives and probabilities; to discuss the meaning and use of vocabulary of conditionality; and to actively apply it in relevant learning experiences. On the basis of my findings and the literature, I suggest that the Tier-system, a framework that can be used by teachers striving to select the most pertinent vocabulary to be taught in an educational context (see Section 6.2.4), lends itself to being used in order to select words that enhance the children's ability to communicate about uncertain knowledge and multiple perspectives. The teaching of these words could then be explicitly included in the teaching strategy. Note that, for example, a multilogical topic such as dependency on fossil fuels, offers many more opportunities for developing and integrating vocabulary of conditionality, than a monological topic like identifying trees.

The findings indicate that natural classroom teacher-child interactions provide rich examples of the use of linguistic devices that could be purposely employed to raise the children's language awareness regarding the language of conditionality (see Section 7.2). Classroom discussion could lead to the enhancement of the children's awareness and understanding of how the language of conditionality can be used and this in turn facilitates the development of uncertainty competences such as: being able to interpret what others are communicating about their degree of certainty★ and being able to express one's degree of certainty★. In addition, teachers would be well served by the development of teaching resources that better support them in teaching about complex, uncertain and inter-disciplinary problems. On the other hand, when teachers develop their own materials, they have the opportunity to use language tailored to the objectives of teaching uncertainty competences.

In summary this study suggests that teachers should learn during their in-service (and pre-service) teacher education:

- what uncertainty competences are and why it is important to develop them
- how to employ a teaching strategy that creates learning opportunities for uncertainty competence development
- that natural classroom teacher-child interactions can be employed to raise the children's awareness of language of conditionality
- how to become competent in their use of language of conditionality in the classroom
- how to deliberately teach children the use of language of conditionality
- how to develop teaching resources that support the development of uncertainty competences and include language of conditionality

Implication for practice #2: uncertainty competence development and language of conditionality as key to sustainability education in primary schools

Wals and Langlet (2016) remind us that there is a need for new learning spaces which support individuals in becoming sustainable citizens. In these learning environments teaching and learning break away from current modes of unsustainable thinking and acting, moving away at the same time from hegemonic societal power relations. Incorporating uncertainty competence development in the primary school curriculum could provide a learning environment in which children can begin to develop the competences that will enable them to contribute to sustainable development. Sterling, Glasser, Rieckmann and Warwick (2017) describe, however, the lack of consensus regarding the specific sustainability competences and capabilities, that need to be developed to transition to a more sustainable society. Moreover, an increasing number of scholars (Lozano, Merrill, Sammalisto, Ceulemans & Lozano, 2017; Shepard, Rieckmann & Barth, 2018; Sterling et al., 2017) have shown concern regarding the limited research to date that focusses specifically on the connection between pedagogical approaches and the development of sustainability competences. In addition, Sterling at al. (2017) discuss the fact that 80% of the publications about sustainability competences are focussed on higher education.

My work on uncertainty competence development in the upper primary years contributes in several ways to resolving certain aspects of the ongoing debates. First, it suggests that teachers should incorporate teaching the 20 uncertainty competences (see Table 10.1) if they wish to prepare their learners for dealing with sustainability challenges. Teachers in the upper primary years can begin by focusing on relevant language development. Teaching about the language of conditionality and in other words teaching how to communicate about the uncertainty and complexity inherent to sustainability challenges can form a constructive beginning to the development of uncertainty competences. Secondly, the present study provides a systematic approach to the development of uncertainty competences and the employment of specific pedagogical approaches. Primary teachers can use sustainability topics and learning activities which provide a rich array of learning opportunities for uncertainty competence development, such as inquiry-based learning, classroom debates and small group work,

I have argued on the basis of my study that both the teacher’s employment of and the children’s sensitivity to the language of conditionality are fundamental to the development of the majority of uncertainty competences. The findings of my study and the questions that arose during the research process suggest that there is still a lot to be learned about effective teaching strategies for developing uncertainty competences (see Section 10.6). However, some proposals for education policy can be made at this stage

10.4 Recommendations for education policy

In this section I consider how the findings and the implications for practice have led to two recommendations for the development of education policy in Scotland and potentially in other countries.

Recommendation for policy #1: Uncertainty competences can be incorporated in existing national education frameworks that emphasise skills development.

The development of uncertainty competences seems to fit naturally into education policy’s increasing emphasis on the importance of skill development and preparation for working and living in a rapidly changing and complex world. The Scottish Curriculum for Excellence (Scottish Executive, 2004) could provide a useful structure within which the uncertainty competences that are not (yet) being taught can be articulated and subsequently incorporated into classroom practice alongside the ones that are already being taught. Some competences resembling uncertainty competences, especially ones that are comparable to critical thinking skills, even though not specifically operationalised with managing uncertain knowledge in mind, are already included in the Curriculum for Excellence. Being able to find, evaluate and utilise information, being able to judge the credibility and cognitive authority of information sources, and being able to reason (Tauritz, 2016) are pertinent examples; other uncertainty competences, such as being able to accept not knowing and being able to use uncertainty as a catalyst for creative action (Tauritz, 2016) require further refinement and specification of the desired outcomes.

It may also be possible to utilise existing national education frameworks for this purpose in other countries. It should be noted that the degree to which national education frameworks are prescriptive varies per country. The Scottish Curriculum for Excellence (Scottish Executive, 2004) is less detailed for children from approximately 3 years up to 14 years of age, the broad general education phase, than previous curriculum advice in Scotland. This provides the teachers with more space to use their professional judgement. In addition, curricula can be more or less prescriptive in *what*, *when* and *how* educational objectives should be taught and can therefore potentially have a greater or lesser impact on the teaching strategies the teachers adopt.

Recommendation for policy #2: Developing the language of conditionality can be embedded in the existing Scottish education policy framework by expanding the Second Level Benchmarks for Literacy and English/Numeracy and Mathematics.

I have argued that it is important for teachers to develop children's language awareness to enable them to understand how language can be used to convey degrees of certainty of knowledge, discuss probabilities, and express multiple and sometimes conflicting perspectives. The development of these skills directly relates to the Second Level Benchmarks set by the Scottish Government for Literacy and English, as well as Numeracy and Mathematics (Education Scotland, 2017). These are the standards that each child in the upper primary years is expected to achieve for each curriculum level. Some of the most relevant benchmarks for this study include that the child:

- recognises some techniques used to influence the listener, for example, word choice, emphasis, tone and/or rhetorical questions (p. 6)
- identifies the difference between fact and opinion (p. 8)
- uses knowledge of context clues, word recognition texts, grammar, punctuation and layout to read unfamiliar texts with understanding (p. 9)
- recognises techniques used to influence the reader, for example, word choice, emotive language, rhetorical questions and/or repetition (p. 11)

- draws conclusions about the reliability of data taking into account, for example, the author, the audience, the scale and sample size used (p. 23)
- uses the language of probability accurately to describe the likelihood of simple events occurring (p. 24)

Expanding the currently employed benchmarks might be a way to embed the development of the language of conditionality in an existing education policy framework such as the Curriculum for Excellence. Insights from the field of psycholinguistics concerning the age-related development of the language of conditionality may contribute to determining the appropriate placement of such benchmarks in terms of school year.

10.5 A developmental perspective on Language of Conditionality

During my research, I often queried at what age one can start teaching uncertainty competences (see Section 1.3.3). I searched many years for information regarding how children deal with uncertainty through successive developmental phases. As I became increasingly aware of the importance of the children's awareness regarding language of conditionality for uncertainty competence development, I came to realise how necessary it could be to know during which developmental phases this language awareness could best be stimulated. The psycholinguistic literature offers some useful pointers. As was discussed in Section 6.1, the field of linguistics employs the term *modal language* for language that expresses degrees of certainty and possibility. I will employ these terms in discussing a developmental perspective based on the psycholinguistic literature.

10.5.1 Modal language use to enhance uncertainty competence development

Wilcox (1991) underlines that for an individual to understand the use of modal language, he or she needs to develop (1) an understanding of relative certainty, and (2) the awareness how language can be used to communicate about the speaker's degree of certainty; these abilities correspond with the following uncertainty competences:

- being able to find, evaluate and utilise information
- being able to judge the credibility and cognitive authority of information sources

- being able to respond in accordance with the underlying probabilities
- being able to interpret what others are communicating about their degree of certainty★
- and the ability to express one's own degree of certainty★

Understanding modal language could therefore contribute to, and is arguably essential to, the development of these uncertainty competences and critical thinking skills.

10.5.2 Understanding relative certainty of knowledge in childhood

Developing an understanding of the relative certainty of knowledge corresponds with the uncertainty competence: being able to respond in accordance with the underlying probabilities. According to Bassano et al. (1992), individual children differ considerably in their development regarding the understanding of a speaker's degree of certainty, which evolves gradually during early and middle childhood. They also state that it takes years longer to comprehend that people can be relatively *uncertain* as opposed to being relatively *certain* about something (a belief state), as this requires understanding the more sophisticated concept that situations can be undetermined. Scholars (Moore, Bryant & Furrow, 1989; Moore et al., 1990) indicate that children begin to understand that beliefs may be held with differing degrees of certainty at about four years of age; it is at that age that they start to understand that there is a distinction between the relative certainty of the mental verbs <u>know</u> and <u>think</u>. Moore et al. (1990) explain that "what develops around four years of age is a representational theory of mind … [this] entails the recognition that psychological entities such as beliefs, perceptions, and utterances are representations of reality and thus that they can misrepresent" (p. 729).

10.5.3 Understanding modal language in childhood

In addition to understanding the concept of relative certainty, children also need to learn how people communicate about the certainty of knowledge; this is captured in the uncertainty competences being able to interpret what others are communicating about their degree of certainty★ and the ability to express one's own degree of certainty★. Scholars provide a diverse perspective on children's development of the ability to understand and employ modal expressions, but generally agree that the development progresses gradually with age (Bassano et al., 1992; Day, 2001; Moore et al., 1989; O'Neill & Atance, 2000; Wilcox, 1991). Wilcox (1991) suggests that even though children begin to produce modal expressions in early childhood, most eight-year-olds do not fully comprehend the use of modal language. Bassano et al. (1992) observed a gradual increase in response to the speaker's linguistic cues by the six-year-old children in their study. Only the eight-year-olds recognised the conditions that characterise uncertainty. The single publication I encountered focusing on children in the same age group as the P6/P7 children in my study was written by Coates (1988). She found that, although eight-year-old children are grammatically competent, they possess only a basic set of modal expressions. The twelve-year-old children in her study showed a much more advanced use of modal language, which, nonetheless, was not fully developed and clearly differed from that of adults.

In conclusion, children start developing sensitivity towards, as well as the use of, modal language in early childhood. The few scholars (Coates, 1988; Wilcox, 1991) who studied these developments in children in middle childhood report that children between eight and twelve years of age are further refining their use of modal language. This supports my suggestion to facilitate the children's understanding and stimulate the use of the language of conditionality in the upper primary years. Coates (1988) points to an important lacuna in the linguistic literature, in that most research has focused on modal language development in children younger than five years. The dearth of studies regarding the development of modal language during middle childhood and adolescence is especially relevant if we look at the issues discussed in the critical thinking literature. Research has revealed, for example, that adolescents and adults often have difficulty accurately assessing source trustworthiness (Coiro et al., 2015; Hobbs, 2017; Julien & Barker, 2009). So, what has happened (or perhaps has not happened) with respect to these children, who began learning modal language in childhood, but fall short when it comes to the development of uncertainty competences later on? Further research crossing the boundaries of the fields of psycholinguistics, child development and education seems warranted.

10.6 Exploring new trails – Recommendations for further research

As my PhD project comes to a close, I cannot help but think about all the further directions that this research could take. At the start, I had ambitious ideas about observing lessons, changing elements and observing a revised version. I was advised to make a beginning by observing what was already happening in the classroom before thinking of changing things. From this I gained invaluable insights regarding the concept of uncertainty competences as well as regarding key elements of a learning environment and teaching strategies that facilitate uncertainty competence development. A major finding is the importance of the use of language of conditionality. In Section 10.6.1, I will discuss some of the limitations of my study and in Section 10.6.2, I describe four new trails that I recommend following.

10.6.1 Limitations of the study

There are a number of alternate explanations for particular findings which could not be either confirmed or rejected in the present study. A few which seem particularly relevant are listed below.

Contextual factors

It is possible that the differences in classroom behaviour were not an effect of the teacher's teaching strategy but were instead caused by other contextual factors such as the range of academic abilities of the children, socio-economic background and culture. The teachers were asked about the range of abilities of the children in their class and their descriptions were similar for all classrooms. Differences in socio-economic backgrounds were not highlighted in this study. Nonetheless, children's language experiences can differ in subtle and potentially significant ways that may impact their educational progress (Mercer and Littleton, 2007). It is possible that a study that compares classrooms, for example, in an inner-city school, a suburban school and a rural school, will find differences in the use of language of conditionality or classroom behaviour independent of the teaching strategy.

Teacher confidence and/or experience

The teaching strategy employed in Classroom C created the most learning opportunities for uncertainty competence development. However, Teacher C was also the most experienced teacher in the study. It is possible that if several teachers use the same teaching strategy, that there will still be differences in the number of created learning opportunities, for example, due to the level of confidence and/or experience the teacher has. It could therefore be interesting to develop a teaching strategy which specifies the same learning objectives, topic, learning activities, teaching resources and language of conditionality on the basis of this study, and observe the opportunities for uncertainty competence development that are created when different teachers attempt to implement the same strategy.

Opportunities for uncertainty competence development

I observed one lesson in Classroom A, B, D and E, and three lessons in Classroom C. My study was therefore better suited to analysing the number of learning opportunities created for uncertainty competence development resulting from the employed teaching strategy than to assessing the development of uncertainty competences in the children over time. For example, the observations in Classroom C, where I observed three lessons demonstrated most clearly how the use of language of conditionality affected the children’s classroom behaviour. In this classroom I observed, for example, that the same children who during the first observed lesson fervently expressed that they would believe what scientists say, changed their opinion in subsequent lessons after the teacher challenged their uncritical acceptance of what knowledge authorities told them and encouraged questioning the evidence they based their assertions on. This exemplifies the processes of ongoing negotiation of meaning through talk and interaction over time described by Neil Mercer (2010). I suggest that further research regarding uncertainty competence development in classrooms should incorporate observations in at least three lessons per classroom to shed more light on classroom developments in response to the employed teaching strategies.

Generalisability

A larger number of cases would have had the potential to generate a more comprehensive range of teaching strategies for the development of uncertainty competences. In the opinion of the author, an exhaustive catalogue of teaching strategies has likely not been achieved in the present study. Nonetheless, the in-depth analysis led to a deeper understanding of uncertainty competence development. In addition, the thick descriptions of the cases make it possible for the reader to ascertain the relevance of the findings to their specific interests (see Section 3.8.2).

Language analysis

My background previous to the undertaking of this study was in the field of learning for sustainability rather than language development. I discovered the work of Ellen Langer during my literature research into the competences an individual might need to be able to handle uncertainty employing search terms including uncertainty, ambiguity, complexity, doubt, risk, probability, knowledge authority, learning for sustainability, teaching, primary education, decision making, competence, capability. (See 2.4.4 and 3.74) and found it particularly relevant to my interests. As a result, I did not pursue other ways in which the classroom language I observed might have been fruitfully explored. For example, Mercer (2010), characterises sociolinguistics as "the relationship between the forms and structures of language and its uses in society" (p.7). Scholars such as Mercer and Littleton (2007) employ sociocultural theory which acknowledges that thinking, communication and learning are shaped by culture and understandings are co-created. Similarly, Halliday's Systemic Functional Linguistics describes how language makes meaning in context (Fontaine, Bartlett and O'Grady, 2013). These insights suggest that observations in classrooms drawn from different cultures might have led to different conclusions with respect to the development of uncertainty competences.

10.6.2 Further research

In Section 10.6.1 I discussed some of the limitations of my study and I made some suggestions leading essentially to ways in which my research could be expanded in terms of variety of school locations, the number of observations per classroom and the total number of classrooms observed or controlled for variations in teaching experience. In this section I propose four new and exciting trails for further research.

Recommendations for research #1: How can teachers best strike a balance between unconditional and conditional language in relation to the children's uncertainty competence development?

Langer's research focused on written instructions, which are phrased either unconditionally or conditionally. She arrived at the conclusion that conditional instructions are preferable, as they can lead to more mindful behaviour. My findings led to similar conclusions. However, I wonder if the mixture of unconditional and conditional language that I heard in most classrooms might not reflect a more natural way of speaking and teaching about complex issues. The language observed in this study can be placed along a continuum, ranging from unconditional to conditional and more often than not found at points in between.

- What are the effects of a mixture of conditional and unconditional language on uncertainty competence development versus uniformly unconditional or conditional language?
- Could a mixture provide some structure and certainty without forfeiting the opportunity for learners to develop a flexible, yet critical mind-set?
- And what is the effect on uncertainty competence development when the use of language of conditionality is made explicit in classroom discussions?

It would be interesting to develop experiments around the same complex topic and containing the same information but presented in different formats. I also wonder if there is a difference between written or spoken instructions with respect to conditional language. Langer's experiments focused on written instructions. However, especially in primary schools, instructions are often given verbally.

- Would verbal conditional instructions generate findings similar to Langer's?
- And what might the effects be of first providing verbal instructions in unconditional or conditional language, and then providing written instructions in the opposite format?

There are many comparable comparative enquiries that could be devised. The better we understand these processes the better scholars will be able to give teachers advice that could lead to the enhancement of uncertainty competence development in educational settings.

Recommendations for research #2: What are the effects of the teacher's non-verbal communication regarding the certainty of knowledge on the children's uncertainty competence development?

The current study focused on the oral and written language of conditionality, although non-verbal cues were sometimes noted. It could be interesting in future research to look into the use of non-verbal communication regarding the certainty of knowledge. This might lead to a fourth part of the model of language of conditionality: *non-verbal communication of conditionality*. Caronia (2014) provides examples of non-verbal communication as it is employed in everyday communication regarding the certainty of knowledge:

> Fillers, pauses, latency of response, rising intonation are relevant cues used for both communicating and inferring uncertainty. Some syntagmatic combinations (e.g. rising intonation, pause and hesitation) appear to lead to a stronger degree of perceived uncertainty than others (e.g. rising intonation plus pause). Interestingly enough, also visual cues (smiles, funny faces, raising of eyebrows or head) are used to detect uncertainty in talk. (p. 26)

Questions of interest might be:

- How accurate are children at employing and/or deciphering facial expressions, tone of voice, body movements and gestures when it comes to assessing the degree of certainty that is being expressed?
- Are the teachers aware of the non-verbal communication of conditionality they are employing in their interactions with the children?
- What is the effect on uncertainty competence development when the teacher's verbal and non-verbal cues provide the children with conflicting information?

Recommendations for research #3: What opportunities for uncertainty competence development can be afforded by varied physical settings and by diverse teaching strategies focused on direct experience?

As this was a first attempt at doing empirical research focused on uncertainty competence development, it made sense to control the number of variables by focusing on lessons in classrooms. This also meant that there were fewer methodological challenges regarding, for example, the recording of the verbal teacher-child interactions. The findings suggest that a classroom affords possibilities for the development of uncertainty competences. However, other more complex and uncertain physical settings may afford even more possibilities. Examples could include inquiry-based projects that focus on finding solutions for messy real-world problems, school grounds greening involving the participation of children and the ambiguous and contested planning process that may ensue (Mannion, 2005), taking part in concrete conservation efforts (e.g. restoring a local stream), or field trips, such as are described in Higgins (2001), during which students go kayaking and encounter the rich natural heritage of a place, leading to conversations about diverse topics such as ecology, land management, geology, and the student's relationships with the land and each other. Examining these more complex and uncertainty rich learning environments suggests itself as a useful area of investigation.

Recommendations for research #4: How do children perceive and experience lessons about complex and uncertain (sustainability) topics?

To achieve a more rounded understanding of uncertainty competence development, I suggest the relevance of investigating the children's perceptions of lessons about complex and uncertain topics. For example, I discovered during the focus group interviews with the children that feelings of confusion were sometimes present both during and after the lesson. During the subsequent teacher interviews, it became clear that the teachers had not considered talking to the children about their feelings while being confronted with complex and uncertain topics. Purposeful exploration of the children's feelings regarding not knowing could serve to strengthen the development of uncertainty competences such as being able to reflect on and (potentially) change one's beliefs regarding uncertainty and being able to accept not knowing (what will happen or what the right answer/action is). Although many scholars (Gordan, 2006; Jordan & McDaniel, 2014a; Tauritz, 2016; Valley, Fu & Jove, 2017) have written about the need for people to learn how to feel comfortable and thrive in the face of uncertainty and *not knowing*, few practical suggestions have been made concerning achieving such a state of being. It might be worthwhile to investigate teaching strategies that encourage inquiry and self-reflection, and that overtly recognise the students' confusion as a constructive state of being.

10.7 Revised List of Uncertainty Competences

It is time to take a final look at the concept of uncertainty competences which has been at the heart of this research. I began this study with the literature-based concept of uncertainty competences as discussed in Tauritz (2012), and an overview of teaching methods gleaned from the literature that could be employed to develop these competences. During the initial literature review phase of the present study I further refined my ideas, which resulted in the initial list of uncertainty competences expanding from the nine competences described in Tauritz (2012) to 17 competences (Tauritz, 2016). During the data analysis phase new insights emerged from the data. This, together with further consultation of the literature, led to further revision of the list of uncertainty competences, which now features 20 competences (see Table 10.1).

The list of uncertainty competences consists of a threefold categorisation: 'Learning to reduce uncertainty', 'Learning to tolerate uncertainty' and 'Learning to cherish uncertainty'. The teachers in my study were generally more familiar with competences from the first and least familiar with competences from the last category. Three new uncertainty competences emerged from the data and were added to the category 'Learning to reduce uncertainty'. The first new competence is: being able to conduct research on complex and uncertain topics★ (see Section 8.3). This competence had initially been subsumed in the competence being able to find information. It became clear during the study, however, that doing research as a way of reducing uncertainty should be treated as a separate uncertainty competence. This perspective is supported by various scholars (Butler, 1978; De Haan, 2010; Wiek et al., 2015) who recognise being able to conduct research as an important competence for finding answers to complex questions.

The two new competences that deal with communicating about degrees of certainty are: being able to interpret what others are communicating about their degree of certainty★ and being able to express one's own degree of certainty★ (see Section 6.2). The emergence of these competences reflects my growing awareness of the many abilities individuals may need to develop in order to be able to manage uncertainty and complexity. A study by Wilcox (1991) makes a similar distinction between understanding that a person can be more or less certain about something, and comprehending the ways in which one can communicate about the degree of certainty of knowledge (see Section 10.5). Although communication skills are often mentioned among the important competences individuals need to develop in preparation for living and working in a rapidly changing world (Paul, 1995; Wiek, Withycombe & Redman, 2011; Wiek et al. 2015), it is arguable on the basis of my findings that individuals also need to develop competences that specifically deal with communicating about the certainty of knowledge (or lack thereof). This is one of the reasons that I consider it so important that children learn the language of conditionality (see Chapters 5-8). Table 10.1 below shows the Revised List of Uncertainty Competences.

Learning to reduce uncertainty
1. Being able to find, evaluate and utilise information (specific knowledge)
2. Being able to judge the credibility and cognitive authority of information sources
3. Being able to conduct research on complex and uncertain topics
4. Being able to reason (inductive and deductive reasoning)
5. Being able to respond in accordance with the underlying probabilities
6. Being able to prioritise among many urgent issues
7. Being able to formulate a plan of action to deal with uncertainty
8. Being able to employ previous experience
9. Being able to assess one's own ability to achieve a desired outcome
10. Being able to engage a supportive network
11. Being able to work in teams with mixed knowledge, skills and experience
12. Being able to use one's intuition as a source of information
13. Being able to interpret what others are communicating about their degree of certainty
14. Being able to express one's beliefs about one's own degree of certainty
Learning to tolerate uncertainty
15. Being able to accept not knowing (what will happen or what the right answer/action is)
16. Being able to reflect on and (potentially) change one's beliefs regarding uncertainty
17. Being able to understand people with different perspectives
Learning to cherish uncertainty
18. Being able to use uncertainty as a catalyst for creative action
19. Being able to entertain an enquiring mind
20. Being able to employ lateral thinking

Table 10.1: Revised List of Uncertainty Competences

10.8 Concluding thoughts

I conclude Chapter 10, as well as my thesis, by reflecting on a statement made by Langer with which I introduced this chapter. In it she tells us that the real risk lies not in fearing that learners will believe in nothing if we ask them to question, but in that if we do not, they will not be able to find answers in a rapidly changing, complex and uncertain world. The language of conditionality has the potential to encourage learners to examine multiple perspectives. In stimulating a conditional perspective, it supports questioning. Without asking questions, how can we expect to find answers? And how then could we find answers to the pivotal sustainability challenges of our time? It is time to embrace uncertainty and acknowledge it as a fundamental driving force for teaching. By becoming ourselves language of conditionality proficient, we can assist learners in acquiring the uncertainty competences that they will need to meet the challenges before them.

The Road goes ever on and on,

Down from the door where it began.

Now far ahead the Road has gone,

And I must follow, if I can,

Pursuing it with eager feet,

Until it joins some larger way

Where many paths and errands meet.

And whither then? I cannot say

J.R.R. Tolkien, The Lord of the Rings

References

Aarts, B., Chalker, S. & Weiner, E. (2014). *Oxford Dictionary of English Grammar* (2nd ed.). Oxford, UK: Oxford University Press.

Abma, T.A. & Stake, R.E. (2014). Science of the Particular: An Advocacy of Naturalistic Case Study in Health Research. *Qualitative Health Research*, 24(8), 1150-1161.

Acredolo, C. & Horobin, K. (1987). Development of relational reasoning and avoidance of premature closure. *Developmental Psychology*, 23(1), 13-21.

Ahsan, M. & Musteen, M. (2011). Flexibility, learning, and control: entry mode choice under uncertainty. *Current Topics in Management*, 15, 199-224.

Alexander, R. (2006). *Towards Dialogic Teaching. Rethinking classroom talk*. Cambridge, UK: Dialogos.

Alexander, P.A. &Murphy, P.K. (1999). Nurturing the seeds of transfer: a domain-specific perspective. *International Journal of Education Research*, 31(7), 561-576.

Allen, B. (2014). Creativity as threshold – learning and teaching in a liminal space. In C. O'Mahony, A. Buchanan, M. O'Rourke & B. Higgs (Eds.), *Threshold Concepts: From Personal Practice to Communities of Practice. Proceedings of the National Academy's Sixth Annual Conference and the Fourth Biennial Threshold Concepts Conference* (pp. 31-37). [E-publication] (Dublin, Ireland, June 27-29, 2012). National Academy for Integration of Research, Teaching and Learning.

Ananiadou, K. & Claro, M. (2009). *21st Century Skills and Competences for New Millennium Learners in OECD Countries*, OECD Education Working Papers (No. 41). Paris, France: OECD Publishing.

Andersen, J. (2004). *Analyzing the role of knowledge organization in scholarly communication: An inquiry into the intellectual foundation of knowledge organization* (Doctoral dissertation, Department of Information Studies, Royal School of Library and Information Science, Copenhagen, Denmark).

Anderson, R. (2008). Implications of the information and knowledge society for education. In J. Voogt & G. Knezek (Eds.), *International Handbook of*

Information Technology in Primary and Secondary Education (pp. 5-22). New York, NY: Springer.

Anderson, C. & McCune, V. (2013). Facing an uncertain future: curricula of dualities. *Curriculum Journal*, 24(1), 153-168.

Anderson, L., Krathwohl, D. & Bloom, B. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Abridged ed.). New York, NY: Longman.

Armstrong, D., Gosling, A., Weinman, J. & Marteau, T. (1997). The place of inter-rater reliability in qualitative research: an empirical study. *Sociology*, 31(3), 597-606.

Baillie, E.M. & Butcher, E.R. (2012). *Priceless or Worthless? The world's most threatened species*. London, UK: Zoological Society of London.

Banerjee, N. & Lee, J. (2017). Science Teachers Respond to Climate Materials Sent by Heartland Institute. *Inside Climate News*. Retrieved from https://insideclimatenews.org/news/22122017/science-teachers-heartland-institute-anti-climate-booklet-survey

Barbour, R. (2001). Checklists for improving rigour in qualitative research: a case of the tail wagging the dog? *British Medical Journal*, 322(7294), 1115-1117.

Barnes, R., Gause, D. & Way, E. (2008). *Teaching the Unknown and the Unknowable in Requirements Engineering Education*. Requirements Engineering Education and Training 2008, Barcelona, 30-37. doi:10.1109/REET.2008.6

Barnett, R. (2007). *A Will to Learn: Being a Student in an Age of Uncertainty*. Maidenhead, UK: Society for Research into Higher Education & Open University Press.

Barnett, R. (2011). Learning about learning: a conundrum and a possible resolution. *London Review of Education*, 9(1), 5-13.

Barnett, R. (2012). Learning for an unknown future. *Higher Education Research & Development*, 31(1), 65-77. doi:10.1080/07294360.2012.642841

Barth, M., Godemann, J., Rieckmann, M. & Stoltenberg, U. (2007). Developing key competencies for sustainable development in higher education. *International Journal of Sustainability in Higher Education*, 8(4), 416-430.

Baruah, J. & Paulus, P. (2008). Effects of Training on Idea Generation in Groups. *Small Group Research*, 39(5), 523-541.

Basiago, A.D. (1995). Methods of defining 'sustainability'. *Sustainable Development*, 3(3), 109-119.

Bassano, D., Hickmann, M. & Champaud, C. (1992). Epistemic modality in French children's discourse: To be sure or not to be sure? *Journal of Child Language*, 19(2), 389-413.

Baxter, P. & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, 13(4), 544-559.

Bazeley, P. (2013). *Qualitative data analysis. Practical Strategies*. Los Angeles, CA: SAGE Publications.

Bazeley, P. & Jackson, K. (2013). *Qualitative Data Analysis with Nvivo* (2nd ed.). Los Angeles, CA: SAGE Publications.

Beames, S., Higgins, P. & Nicol, R. (2012). *Learning outside the classroom*. New York, NY: Routledge, Taylor & Francis Group.

Beames, S. & Brown, M. (2016). *Adventurous Learning: A Pedagogy for a Changing World*. New York, NY: Routledge, Taylor & Francis Group.

Beck, S.R., Robinson, E.J. & Freeth, M.M. (2008). Can children resist making interpretations when uncertain? *Journal of Experimental Child Psychology*, 99(4), 252-270. doi:10.1016/j.jecp.2007.06.002

Beck I., McKeown M. & Omanson R. (1987). The effects and uses of diverse vocabulary instructional techniques. In M. Curtis & M. McKeown (Eds.), *The nature of vocabulary acquisition* (pp. 147-163). Hillsdale, NJ: Erlbaum.

Beck, I.L., McKeown, M.G. & Kucan, L. (2013). *Bringing words to life, Second Edition: Robust vocabulary instruction.* New York, NY: The Guilford Press.

Beghetto, R. A. (2016). Leveraging micro-opportunities to address macroproblems: Toward an unshakeable sense of possibility thinking. In D. Ambrose & R. J. Sternberg (Eds.). *Creative intelligence in the 21st Century* (pp. 159-174). Rotterdam, Netherlands: Sense Publishers

Beghetto, R.A. (2017). Inviting Uncertainty into the Classroom. *Educational Leadership*. 75(2), 20-25.

Bell, S., Harkness, S. & White, G. (Eds.) (2007). *Storyline: Past, present & future*. Glasgow: Enterprising Careers, University of Strathclyde.

Bernard, H.R. (2006). *Research methods in anthropology: Qualitative and quantitative approaches* (4th ed.). Lanham, MD: Rowman AltaMira.

Biemans, H., Nieuwenhuis, L., Poell, R., Mulder, M. & Wesselink, R. (2004). Competence-based VET in the Netherlands: background and pitfalls. *Journal of Vocational Education and Training*, 56(4), 523-538.

Biemiller, A. (2003). Vocabulary: needed if more children are to read well. *Reading Psychology*, 24(3-4), 323-335.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M. & Rumble, M. (2012). Defining 21st century skills. In P. Griffin, B. McGaw & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17-66). Dordrecht, Netherlands: Springer.

Birt, L., Scott, S., Cavers, D., Campbell, C. & Walter, F. (2016). Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation? *Qualitative Health Research*, 26(13), 1802-1811.

Bishop, S. (2004). Mindfulness: A Proposed Operational Definition. *Clinical Psychology: Science and Practice*, 11(3), 230-241.

Blaikie, N. (2004). Abduction. In M. Lewis-Beck, A. Bryman & T.F. Liao (Eds.), *The SAGE Encyclopedia of Social Science Research Methods* (pp. 1-2). Thousand Oaks, CA: SAGE Publications.

Blanchet-Cohen, N. (2008). Taking a stance: child agency across the dimensions of early adolescents' environmental involvement. *Environmental Education Research*, 14(3), 257-272. doi: 10.1080/13504620802156496

Bloom, B.S. (Ed.), Engelhan, M.D., Furst. E.J., Hill, W.H. & Krathwohl. D.R. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain*. New York, NY: David McKay.

Boler, M. (1999). *Feeling Power: Emotions and Education*. New York, NY: Routledge.

Bolhuis, S. (2003). Towards process-oriented teaching for self-directed lifelong learning: a multidimensional perspective. *Learning and Instruction*, 13(3), 327-347.

Bracken, S. (2010). Discussing the importance of ontology and epistemology awareness in practioner research. *Worcester Journal of Learning and Teaching*, Issue 4, 1-9. Retrieved from https://eprints.worc.ac.uk/843/

Bradshaw, G. & Borchers, J. (2000). Uncertainty as Information: Narrowing the Science-policy Gap. *Conservation Ecology*, 4(1), 1-13.

Branch, G., Rosenau, J. & Berbeco, M. (2016). Climate education in the classroom: cloudy with a chance of confusion. *Bulletin of the Atomic Scientists*, 72(2), 89-96. doi: 10.1080/00963402.2016.1145906

Bråten, I., Strømsø, H. & Salmerón, L. (2011). Trust and mistrust when students read multiple information sources about climate change. *Learning and Instruction*, 21(2), 180-192.

British Educational Research Association (2011). *Ethical guidelines for educational research*. London, UK: BERA. Retrieved from https://www.bera.ac.uk/wp-content/uploads/2014/02/BERA-Ethical-Guidelines-2011.pdf

Bromley, K. (2002). Stretching Students' Vocabulary, grades 3-8. New York, NY: Scholastic.

Brookfield, S. (2012). *Teaching for Critical Thinking: Tools and Techniques to Help Students Question Their Assumptions*. San Francisco, CA: John Wiley & Sons.

Brown, M. (2008). Comfort zone: model or metaphor? *Australian Journal of Outdoor Education*, 12(1), 3-12.

Brown, M. & Beames, S. (2017). Adventure education: Redux. *Journal of Adventure Education and Outdoor Learning*, 17(4), 294-306. doi: 10.1080/14729679.2016.1246257

Buchanan, S., Harlan, M., Bruce, C. & Edwards, S. (2016). Inquiry based learning models, information literacy, and student engagement: A literature review. *School Libraries Worldwide*, 22(2), 23-39.

Buckingham, W. (2014). Communicating Not-Knowing: Education, Daoism, and Epistemological Chaos. *China Media Research*, 10(4), 10-19.

Buckingham Shum, S. & Deakin, R. (2012). *Learning Dispositions and Transferable Competencies: Pedagogy, Modelling and Learning Analytics. Proceedings 2nd International Conference on Learning Analytics & Knowledge* (29 Apr-2 May 2012, Vancouver, BC). New York, NY: ACM Press.

Butler, F. (1978). The Concept of Competence: An Operational Definition. *Educational Technology*, 18(1), 7-18.

Byrnes, J. & Overton, W. (1986). Reasoning About Certainty and Uncertainty in Concrete, Causal, and Propositional Contexts. *Developmental Psychology*, 22(6), 793-799.

Camillus, J. (2008). Strategy As a Wicked Problem. *Harvard Business Review*, 86(5), 89-106.

Caronia, L. (2014). Communicating certainty and uncertainty in everyday life: an introduction. *Journal of Theories and Research in Education*, 9(1), 9-33.

Carter, R. (2003). Key Concepts in ELT: Language Awareness. *ETL Journal*. 57(1), 64-65.

Cervetti, G., Barber, J., Dorph, R. Pearson, D. & Goldschmidt, P. (2012). The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of research in science teaching*, 49(5), 631-658.

Chanowitz, B. & Langer, E. (1981). Premature cognitive commitment. *Journal of Personality and Social Psychology*. 41(6), 1051-1063.

Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. London, UK: SAGE Publications.

Charmaz, K. (2011). Grounded Theory Methods in Social Justice Research. In N.K. Denzin & Y. Lincoln (Eds.), *Handbook of Qualitative Research* (4th ed.) (pp. 359-380). Thousand Oaks, CA: SAGE Publications.

Charmaz, K. (2016). The Power of Constructivist Grounded Theory for Critical Inquiry. *Qualitative inquiry*, 23(1), 34-45.

Chemero, A. (2003). An Outline of A Theory of Affordances. *Ecological Psychology*, 15(2), 181-195.

Chesterfield, R. (1997). *Classroom observation tools: Improving educational quality (IEQ) project*. Institute for International research in collaboration with Juarez and Associates, Inc. & The University of Pittsburgh.

Chesters, S.D. (2012). *The Socratic Classroom: Reflective Thinking Through Collaborative Inquiry*. Rotterdam, Netherlands: Sense Publishers.

Chu, S.K.W., Chow, K. & Tse, S.K. (2011). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library and Information Science Research, 33*(2), 132-143.

Clapper, T. C. (2010). Creating the safe learning environment. *PAILAL, 3*(2), 1-6.

Claxton, G. (2001). *Wise Up: Learning to live the Learning Life*. Stafford, UK: Network Educational Press.

Coates, J. (1987). Epistemic modality and spoken discourse. *Transactions of the Philological Society*, 85(1), 110-131.

Coates, J. (1988). The acquisition of the meanings of modality in children aged eight and twelve. *Journal of Child Language*, 15(2), 425-434.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research methods in Education* (6th ed.). Abingdon, UK: Routledge.

Cohen, E. & Lotan, R. (2014). *Designing Groupwork: Strategies for the Heterogeneous Classroom* (3rd ed.). New York, NY: Teachers College Press.

Coiro, J., Coscarelli, C., Maykel, C. & Forzani, E. (2015). Investigating Criteria That Seventh Graders Use to Evaluate the Quality of Online Information. *Journal of Adolescent & Adult Literacy*, 59(3), 1-11.

Collins Dictionary. (n.d.). Fact. Retrieved February13, 2018 from https://www.collinsdictionary.com/dictionary/english/fact

Comer, J., Roy, A., Furr, J., Gotimer, K., Beidas, R., Dugas, M. & Kendall, P. (2009). The Intolerance of Uncertainty Scale for Children: A Psychometric Evaluation. *Psychological Assessment*, 21(3), 402-411.

Conklin, J. (2001). Chapter 1 Wicked problems and social complexity. In J. Conklin, *Dialogue Mapping: Building Shared Understanding of Wicked Problems* (pp. 1-20). CogNexus Institute. Retrieved from http://cognexus.org/wpf/

wickedproblems.pdf

Conklin, J., Basadur, M. & VanPatter, G. K. (2007). Rethinking wicked problems: unpacking paradigms, bridging universes. *NextD journal*, 10(1), 1-29.

Cotton, K. (2001). *Classroom Questioning*. School Improvement Research Series. Close-up #5. North West Regional Educational Laboratory. Retrieved from https://educationnorthwest.org/resources/school-improvement-research-series

Creswell, J. & Miller, D. (2000). Determining Validity in Qualitative Inquiry. *Theory into practice*, 39(3), 124-130.

Creswell, J. (2007). *Qualitative Inquiry & Research Design. Choosing Among Five approaches*. (2nd ed.) Thousand Oaks, CA: SAGE Publications.

Cronin, A., Alexander, V., Fielding, J., Moran-Ellis, J. & Thomas, H. (2008). 34. The Analytic Integration of Qualitative Data Sources. In P. Alasuutari, L. Bickman & J. Brannen (Eds.). *The SAGE Handbook of Social Research Methods*, (pp. 572-584). London, UK: SAGE Publications.

Crutzen, P.J. (2002). Geology of mankind. *Nature*, 415(6867), 23.

Dallimore, E.J., Hertenstein, J.H. & Platt, M.B. (2004). Classroom participation and discussion effectiveness: student-generated strategies. *Communication Education*, 53(1), 103-115.

Davenport, C. & Pagnini, F. (2016). Mindful Learning: A Case Study of Langerian Mindfulness in Schools. *Frontiers in Psychology*, 7(1372), 1-5.

Davies, M. & Barnett, R., (Eds.) (2015). *The Palgrave handbook of critical thinking in higher education*, 409-426. New York, NY: Palgrave Macmillan.

Dawson, R. (2000). Critical Thinking, Scientific Thinking, and Everyday Thinking: Metacognition about Cognition. *Academic Exchange Quarterly*, 4(3), 76-83.

Day, C. (2001). A Developmental Perspective on Modal Verb Use by French-Speaking Children. In K. Nelson, A. Aksu-Koç & C. Johnson (Eds.), *Children's language Volume 11: Interactional contributions to language development* (pp. 95-122) Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

De Bono, E. (1971). *The Use of Lateral Thinking*. Harmondsworth, UK: Penguin Books.

De Bono, E. (1990). *Lateral Thinking. A Textbook of Creativity*. London, UK: Penguin Books.

De Haan, G. (2010). The development of ESD-related competencies in supportive institutional frameworks. *International Review of Education*, 56(2-3), 315-328.

Denzin, N. & Lincoln, Y. (2011). *The Sage handbook of qualitative research* (4th ed.) Thousand Oaks, CA: SAGE Publications.

Department for Children, Schools and Families (2008). *Teaching effective vocabulary: What can teachers do to increase the vocabulary of children who start education with a limited vocabulary*. Nottingham, UK: Department of Children, Schools, and Family.

Department for Education (2013). *The national curriculum in England: Key stages 1 and 2 framework document, September 2013*. Retrieved from https://www.gov.uk/government/collections/national-curriculum

Derry, S. (Ed.) (2007). *Guidelines for Video Research in Education: Recommendations from an Expert Panel*. Chicago, IL: Data Research and Development Center. Retrieved from https://drdc.uchicago.edu/what/video-research-guidelines.pdf

De Vos, K. (2006). *Brainstormen 50.000 ideeën per dag! Het ultieme handboek*. Amsterdam, Netherlands: Pearson Education Benelux.

Dewey, J. (1910). *How we think*. Lexington, MA: D.C. Heath & Company.

Dewey, J. (1916). *Democracy and Education. An Introduction to the Philosophy of Education*. New York, NY: The Free Press.

Dewey, J. (2010). *How we think*. Boston, New York, NY: D. C. Heath & Company.

DiCocco-Bloom, B. & Crabtree, B. (2006). The Qualitative research interview. *Medical Education*, 40(4), 314-321.

Dillon, J.T. (2004). *Questioning and Teaching. A Manual of Practice*. Eugene, OR: Wipf and Stock Publishers.

Doyle, W. & Carter, K. (1984). Academic Tasks in Classrooms. *Curriculum Inquiry, 14*(2), 129-149.

Drisko, J. & Maschi, T. (2015). *Content Analysis*. Oxford, UK: Oxford University Press.

Duke, N.K. & Moses, A. M. (2003). *10 research tested ways to build children's vocabulary*. *Scholastic Research Paper*. New York, NY: Scholastic.

Dumont, H., Instance, D. & Benavides, F. (Eds.) (2010). *The Nature of Learning: Using research to inspire practice*, Educational Research and Innovation. Paris, France: OECD Publishing.

Dweck, C.S. (2007). The Perils and Promises of Praise. *Educational Leadership, 65*(2), 34-39.

Dweck, C. (2012). *Mindset*. London, UK: Constable & Robinson Ltd.

Eames, C. (2017). Climate change education in New Zealand. *Curriculum Perspectives*, 37(1), 99-102. https://doi.org/10.1007/s41297-017-0017-7

Education Council (2006). Recommendation of the European Parliament and the Council of 18 December 2006 on key competencies for lifelong learning. *Brussels: Official Journal of the European Union*, 30(12), 10-18.

Education Scotland (2015). *How good is our school?* (4th ed.). *2015*. Retrieved from https://eric.ed.gov/?id=ED574051

Education Scotland (2017). *Benchmarks: Second Level: All Curriculum Areas. March 2017*. Retrieved from http://dera.ioe.ac.uk/28599/1/SecondLevelBenchmarksAllAreasPDF.pdf

Ehrenfeld, J.D. (2017). Changemaking and engagement in an uncertain world. In *Skills for a Changing World - Meaningful Education in Times of Uncertainty – Collection of essays* (pp. 49-57). Washington D.C.: The Brookings Institute. Retrieved from http://www.brookings.edu/research/meaningful-education-in-times-of-uncertainty

Ellerton, P. (2015). Metacognition and Critical Thinking: Some Pedagogical Imperatives. In M. Davies & R. Barnett (Eds.), *The Palgrave handbook of critical thinking in higher education* (pp. 409-426). New York, NY: Palgrave Macmillan.

Emmel, N. (2014). *Sampling and Choosing Cases in Qualitative Research: A Realist Approach*. London, UK: SAGE Publications Ltd.

English, A. (2013). *Discontinuity in Learning: Dewey, Herbart and Education as Transformation*. Cambridge, UK: Cambridge University Press.

Ennis, R.H. (1985). Goals for a critical thinking curriculum. In A.L. Costa (Ed.), *Developing minds* (pp. 54-57). Alexandria, VA: ASCD.

Estyn (2014). ESDGC: *Progress in education for sustainable development and global citizenship* (June 2014). Cardiff, UK: Estyn. Retrieved from https://www.estyn.gov.wales/thematic-reports/esdgc-progress-education-sustainable-development-and-global-citizenship-june-2014

European Commission (2007). *Key competences for lifelong learning: A European Reference Framework*. Brussel, Belgium: European Commission.

European Commission (2018). *Proposal for a Council Recommendation on Key Competences for Lifelong Learning* (Brussel, January 17, 2018). Retrieved from https://ec.europa.eu/education/sites/education/files/recommendation-key-competences-lifelong-learning.pdf

Ewens, W. (1986). Teaching Using Discussion. *Journal of Management Education*, 10(3), 77-80.

Facione, P.A. (2000). The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship to Critical Thinking Skill. *Informal Logic*, 20(1), 61-84.

Herring, P. (2016). *The Farlex Grammar Book: Complete English Grammar Rules*. Dublin, Ireland: Farlex International.

Fatemi, S.M. (Ed.) (2016). *Critical Mindfulness: Exploring Langerian Models*. Cham, Switzerland: Springer International Publishing.

Festinger, L. (1957). *A theory of cognitive dissonance*. Evanston, IL: Row, Peterson.

Finnish National Board of Education (2004). *National core curriculum for basic education*. Helsinki: FNBE. Retrieved from https://www.oph.fi/english/curricula_and_qualifications/basic_education/curricula_2014

Finnish National Board of Education (2016). *New national core curriculum for basic education: focus on school culture and integrative approach*. Helsinki, Finland: FNBE. Retrieved from https://minedu.fi/en/brochures

Floden, R. & Buchmann, M. (1993). Between routines and anarchy. Preparing teachers for uncertainty. *Oxford Review of Education*, 19(3), 373-382.

Flyvbjerg, B. (2001). 6 The power of example. In B. Flyvbjerg & S. Sampson (Eds.), *Making Social Science Matter: why social inquiry fails and how it can succeed again* (pp. 66-87). Cambridge, UK: Cambridge University Press.

Foley, Y. (2017). Critical literacy. In Street, B. & May, S. (Eds.), *Literacies and Language Education, Encyclopedia of Language and Education* (3rd ed.) (pp. 109-120). Cham, Switzerland: Springer International Publishing.

Fontaine, L., Bartlett, T. & O'Grady, G. (2013). Systemic Functional Linguistics: Exploring Choice. Cambridge, UK: Cambridge University Press.

Forrest, K., Judd, K. & Davison J. (2012). Coming to know within 'healthy uncertainty': an autoethnography of engagement and transformation in undergraduate education. *Teaching in Higher Education*, 17(6), 710-721.

Fraser, S. & Greenhalgh, T. (2001). Coping with complexity: educating for capability. *British Medical Journal*, 323(7316), 799-803.

Free Dictionary. (n.d.). *Scientific fact*. Retrieved 30 August, 2018 from http://www.webster-dictionary.org/definition/scientific%20fact

Freeley, A. & Steinberg, D. (2009). *Argumentation and debate: Critical thinking for reasoned decision making* (12th ed.). Boston, MA: Wadsworth Cengage Learning.

Friedman, W. (2011). Commentary: The past and present of the future. *Cognitive Development*, 26(4), 397-402.

Friedrichs, J. & Kratochwil, F. (2009). On Acting and Knowing: How Pragmatism Can Advance International Relations Research and Methodology. *International Organization*, 63(4), 701-731.

Funtowicz, S. & Ravetz, J. (1990). *Philosophy and methodology of the social sciences: Volume 15 Uncertainty and quality in science for policy*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Funtowicz, S. & Ravetz, J. (1993). Science for the post-normal age. *Futures*, 25(7), 739-755.

Gabella, M.S. (1995). Unlearning Certainty: Toward a Culture of Student Inquiry. *Theory into Practice*, 34(4), 236-242.

Gardiner, S. & Rieckmann, M. (2015). Pedagogies of Preparedness: Use of Reflective Journals in the Operationalisation and Development of Anticipatory Competence. *Sustainability*, 7(8), 10554-10575. doi:10.3390/su70810554

Gardiner, S. (2017). Chapter 17: Futures loss, despair and empowerment work. In P.B. Corcoran, J. Weakland & A.E.J. Wals (Eds.), *Envisioning futures for environmental and sustainability education* (pp. 217-228). Wageningen, Netherlands: Wageningen Academic Publishers.

Gelatt, H.B. (1989). Positive Uncertainty: A New Decision-Making Framework for Counseling. *Journal of Counseling Psychology*, 36(2), 252-256.

General Teaching Council for Scotland (2012). *The Standards for Registration: mandatory requirements for Registration with the General Teaching Council for Scotland* (December 2012). Edinburgh, UK: GTC Scotland.

Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin.

Gibson, F. (2007). Conducting focus groups with children and young people: strategies for success. *Journal of Research in Nursing*, 12(5), 473-483.

Gillham, B. (2000). *Case Study Research Methods*. London, UK: Wellington House.

Glaser, B. & Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research.* New Brunswick, NJ: Aldine Transaction.

Gordon, M. (2006). Welcoming Confusion, Embracing Uncertainty: Educating Teacher Candidates in an Age of Certitude. *Paideusis*, 15(2), 15-25.

Goswami, U. (2004). Chapter Thirteen: Inductive and Deductive Reasoning. In U. Goswami (Ed.), *Blackwell Handbook of Childhood Cognitive Development* (pp. 282-302). Malden, MA: Blackwell Publishers Ltd.

Goverse, T. (2013). *UNEP Year Book 2013: Emerging issues in our global environment*, United Nations Environment Programme.

Graneheim, U.H. & Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today*, 24(2), 105-112.

Greene, S. & Hogan, D. (2005). Exploring Children's Views through Focus Groups. In S. Greene. & D. Hogan (Eds.), *Researching Children's Experience* (pp. 237-252). London, UK: SAGE Publications.

Gregory, R. (1991). Critical Thinking for Environmental Health Risk Education. *Health Education Quarterly*, 18(3), 273-284.

Grenier, S., Barrette, A. & Ladouceur, R. (2005). Intolerance of Uncertainty and Intolerance of Ambiguity: Similarities and differences. *Personality and Individual Differences*, 39 (3), 593-600. doi:10.1016/j.paid.2005.02.014

Greig, A., Taylor, J. & MacKay, T. (2007). *Doing Research with Children*. London, UK: SAGE Publications. doi: http://dx.doi.org/10.4135/9781849209045.n9

Griffin, P., McGaw, B. & Care, E. (2012). *Assessment and Teaching of 21st Century Skills*. Dordrecht, Netherlands: Springer.

Hadley, G. (2015). *English for Academic Purposes in Neoliberal Universities: A Critical Grounded Theory*. Educational linguistics (volume 22). New York, NY: Springer.

Haigh, E., Moore, M., Kashdan, T. & Fresco, D. (2011). Examination of the Factor Structure and concurrent validity of the Langer mindfulness/mindlessness scale. *Assessment*, 18(1), 11-26.

Hall, B.M. (2006) Teaching and learning uncertainty in science: the case of climate change. *Planet*, 17(1), 48-49. doi: 10.11120/plan.2006.00170048

Hall, B.M. (2010). *Teaching uncertainty: The case of climate change.* (Unpublished doctoral dissertation). University of Gloucestershire, Cheltenham, UK.

Hall, B.M. (2011). Threshold Concepts and Troublesome Knowledge: Towards a ‘Pedagogy of Climate Change’? In: S. Haslett, S. Gedye & D. France (Eds.), *Pedagogy of Climate Change* (pp. 25-35), Plymouth, UK: Geography, Earth and Environmental Sciences Subject Centre.

Hall, B.M. (2014). “How Do You Know?” The Threshold Concept, Multi-Disciplinary Approaches and the Age of Uncertainty. In C. O'Mahony, A. Buchanan, M. O'Rourke & B. Higgs (Eds.), *Threshold Concepts: From Personal Practice to Communities of Practice. Proceedings of the National Academy's Sixth Annual Conference and the Fourth Biennial Threshold Concepts Conference* (pp.94-98) [E-publication] (Dublin, Ireland, June 27-29, 2012). National Academy for Integration of Research, Teaching and Learning.

Halpern, D. (2006). 1 The Nature and Nurture of Critical Thinking. In R. Sternberg, H. Roediger III & D. Halpern (Eds.). *Critical Thinking in Psychology* (pp. 1-14). Cambridge, MA: Cambridge University Press.

Hart, R. (1992). *Children’s Participation: From Tokenism to Citizenship. UNICEF Innocenti Essays* (No. 4). Florence, Italy: International Child Development Centre of UNICEF.

Hatch, J. (2002). *Doing Qualitative Research in Education Settings*. New York, NY: State University of New York Press.

Hammersley, M. (2008). Troubles with triangulation. In M. Bergman (Ed.), *Advances in Mixed Methods Research* (pp. 22-36). London, UK: SAGE Publications.

Hamilton, L. & Corbett-Whittier, C. (2013). *Using Case Study in Education Research*. Los Angeles, CA: SAGE Publication.

Harding, R. (2006). Ecologically sustainable development: origins, implementation and challenges. *Desalination*, 187(1), 229-239.

Harris, C. & Rooks, D. (2010). Managing Inquiry-Based Science: Challenges in Enacting Complex Science Instruction in Elementary and Middle School Classrooms. *Journal of Science Teacher Education, 21*(2), 227-240.

Hart, R.A. (1992). *Children's Participation, from Tokenism to Citizenship*. Florence, Italy: UNICEF.

Hauge, K.H. & Barwell, R. (2017). Post-normal science and mathematics education in uncertain times: Educating future citizens for extended peer communities. *Futures*, 91, 25-34.

Healey, R.L. (2012). The Power of Debate: Reflections on the Potential of Debates for Engaging Students in Critical Thinking about Controversial Geographical Topics. *Journal of Geography in Higher Education*, 36(2), 239-257, doi: 10.1080/03098265.2011.619522

Heft, H. (1988). Affordances of children's environments: a functional approach to environmental descriptions. *Children's Environments Quarterly*, 5(3), 29-37.

Henriques, A. & Oliveira, H. (2016). Students' expressions of uncertainty in making informal inference when engaged in a statistical investigation using TinkerPlots. *Statistics Education Research Journal*, 15(2), 62-80.

Higgins, P. (2001). Learning Outdoors: Encounters with Complexity. In P. Becker & J. Schirp (Eds.), *Other Ways of Learning: The European Institute for Outdoor Adventure Education and Experimental Learning, 1996-2006* (pp. 99-110). Marburg, Germany: BSJ.

Higgins, P. (2009). Into the Big Wide World: Sustainable Experiential Education for the 21st Century. *Journal of Experiential Education*, 32(1), 44-60.

Higgins, P. & Christie, B. (2018). 65 Learning for sustainability. In T. Bryce, W. Humes, D. Gillies & A. Kennedy (Eds.), *Scottish Education* (pp. 554-564). Edinburgh, UK: Edinburgh University Press.

Hobbs, R. (2017). Teaching and Learning in a Post-Truth World. *Educational Leadership*, 75(3), 26-31.

Holmboe, E.S., Sherbino, J., Englander, R., Snell, L., Frank, J.R. & on behalf of ICBME Collaborators (2017). A call to action: The controversy of and rational for competency-based medical education. *Medical Teacher*, 39(6), 574-581.

Holmes, J. (2015). *Nonsense: The power of not knowing*. New York, NY: Crown Publishers/ Penguin Random House.

Hoskins, B. & Crick, R.D. (2010). Competences for Learning to Learn and Active Citizenship: different currencies or two sides of the same coin? *European Journal of Education*, 45(1), 121-137.

Huber, G., Sorrentino, R., Davidson, M., Eppler, R. & Roth, J. (1992). Uncertainty orientation and cooperative learning: individual differences within and across cultures. *Learning and individual differences*, 4(1), 1-24.

IPPC (2015). *Climate change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* [The Core Writing Team, Pachauri, R.K. and Meyer, L.A. (Eds.)]. Geneva, Switzerland: IPCC.

IPPC (2018). *Special Report on Global Warming of 1.5ºC*. Incheon, South Korea: Intergovernmental Panel on Climate Change (IPCC). Retrieved from https://www.ipcc.ch/sr15/.

Jabardeen, Y. (2008). A new conceptual framework for sustainable development. *Environment, Development for Sustainable Development*, 10(2), 179-192.

Jan, J.M. & Talif, R. (2017). Questioning strategies and the construction of context in classroom talk. *The English Teacher*, XXXIV, 76-89.

Johnson-Laird, P. & Byrne, R. (2002). Conditionals: A Theory of Meaning, Pragmatics, and Inference. *Psychological Review*, 109(4), 646-678.

Jones, E. (2012). The Emergence of Emergent Curriculum. *YC Young Children*, 67(2), 66-68.

Jones, G.A., Langrall, L.C.W. & Mooney, E.S. (2007). Research in probability: responding to classroom realities. In F.K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 909-955). Charlotte, NC: Information Age Publishing.

Jordan, M. (2010). *Managing uncertainty in collaborative robotics engineering projects: The influence of task structure and peer interaction* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 3417464)

Jordan, M. & Babrow, A.S. (2013). Communication in Creative Collaborations: The Challenges of Uncertainty and Desire Related to Task, Identity, and Relational Goals. *Communication Education*, 62(2), 210-232.

Jordan, M. & McDaniel Jr, R. (2014a). Helping students respond creatively to a complex world. In D. Ambrose, B. Sriraman & K. Pierce (Eds.), *A Critique of Creativity and Complexity: Deconstructing Clichés* (pp. 249-268). Rotterdam Netherlands: Sense Publishers.

Jordan, M. & McDaniel Jr, R. (2014b). Managing Uncertainty During Collaborative Problem Solving in Elementary School Teams: The Role of Peer Influence in Robotics Engineering Activity. *Journal of the Learning Sciences*, 23(4), 490-536.

Jordan, M. (2015). Variation in students' propensities for managing uncertainty. *Learning and Individual Differences*, 38, 99-106.

Julien, H. & Barker, S. (2009). How high-school students find and evaluate scientific information: A basis for information literacy skills development. *Library & Information Science Research*, 31(1), 12-17.

Kabat-Zinn, J. (2003). Mindfulness-Based Interventions in Context: Past, Present, and Future. *Clinical Psychology-Science And Practice, 10*(2), 144-156.

Kajika, Y. (2008). Research core and framework of sustainability science. *Sustainability Science*, 3(2), 215-239.

Kelsey, E. & Armstrong, C. (2012). Finding hope in a world of environmental catastrophe. In A.E.J. Wals & P.B. Corcoran (Eds.), *Learning for Sustainability in times of accelerating change* (pp. 187-200). Wageningen: Wageningen Academic Publishers.

Kember, D., Ha, T.S., Lam, B.H., Lee, A., Ng, S., Yan, L. & Yum, J.C. (1997). The diverse role of the critical friend in supporting educational action research projects. *Educational Action Research*, 5(3), 463-481, doi: 10.1080/09650799 700200036

Kennedy, R. (2007). In-class debates: Fertile ground for active learning and the cultivation of critical thinking and oral communication skills. *International Journal of Teaching & Learning in Higher Education*, 19(2), 183-190.

Kennedy, R. (2009). The power of in-class debates. *Active learning in higher education*, 10(3), 225-236.

Kinos, J., Robertson, L., Barbour, N. & Pukk, M. (2016). Child-Initiated Pedagogies: Moving toward Democratically Appropriate Practices in Finland, England, Estonia, and the United States. *Childhood Education*, 92(5), 345-357.

Kirschner, P. A. (2002). Can we support CSCL? Educational, social and technological affordances for learning. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL?* (pp. 61-91). Heerlen, Netherlands: Open Universiteit Nederland.

Klieme, E., Hartig, J. & Rauch, D. (2008). The concept of competence in educational contexts. In J. Hartig, E. Klieme & D. Leutner (Eds.), *Assessment of competencies in educational contexts* (pp. 3-22). Ashland, OH: Hogrefe & Huber Publishers.

Koerber, S., Mayer, D., Osterhaus, C., Schwippert, K. & Sodian, B. (2015). The Development of Scientific Thinking in Elementary School: A Comprehensive Inventory. *Child Development*, 86(1), 327-336.

Kotter, J.P. (2008). *A Sense of urgency*. Cambridge, MA: Harvard Business Press.

Krathwohl, D. R. (2002). A revision of Bloom's Taxonomy: an overview. *Theory into Practice*, 41(4), 212-218.

Kreber, C. (2009). Supporting Student Learning in the Context of Diversity, Complexity and Uncertainty. In C. Kreber (Ed.), *The University and its Disciplines: Teaching and Learning Within and Beyond Disciplinary Boundaries* (pp. 4-18). New York, NY: Routledge.

Krefting, L. (1991). Rigor in Qualitative Research: The Assessment of Trustworthiness. *American Journal of Occupational Therapy*, 45(3), 214-222.

Kuckartz, U. (2014). Qualitative Text Analysis: A Guide to Methods, Practice & Using Software. Los Angeles, CA: SAGE Publications.

Kyriacou, C. (1998). *Essential Teaching Skills* (2nd ed.) Cheltenham, UK: Nelson Thornes.

Lagattuta, K.H. & Sayfan, L. (2011). Developmental changes in children's understanding of future likelihood and uncertainty. *Cognitive Development*, 26(4), 315-330.

Lane, H.B. & Allen, S.A. (2010). The Vocabulary-Rich Classroom: Modeling Sophisticated Word Use to Promote Word Consciousness and Vocabulary Growth. *The Reading Teacher*, 63(5), 362-370.

Langer, E. & Piper, A. (1987). The prevention of mindlessness. *Journal of Personality and Social Psychology*, 53(2), 280-287.

Langer, E., Hatem, M., Joss, J. & Howell, M. (1989). Conditional Teaching and Mindful learning. The Role of Uncertainty in Education. *Creativity Research Journal*, 2(3), 139-150. doi: 10.1080/10400418909534311

Langer, E. (1992). Matters of Mind: Mindfulness/Mindlessness in Perspective. *Consciousness and Cognition*, 1(4), 289-305.

Langer, E. (1993). A mindful education. *Educational Psychologist*, 28(1), 43-50.

Langer, E. (1997). *The Power of Mindful Learning*. Cambridge, MA: Da Capo Press.

Langer, E. (2000). Mindful Learning. *Current Directions in Psychological Science*, 9(6), 220-223.

Langer, E. & & Moldoveanu, M. (2000). The Construct of Mindfulness. *Journal of Social Issues*, 56(1), 1-9.

Langer, E. (2014). *Mindfulness. 25th Anniversary edition*. Cambridge, MA: Da Capo Press.

Langer, E. (2016). *The Power of Mindful Learning.* (2nd ed.). Boston, MA: Da Capo Lifelong Books.

Langsdale, S. (2008). Communication of Climate Change Uncertainty to Stakeholders Using the Scenario Approach. *Journal of Contemporary Water Research & Education*, 140(1), 24-29.

Learning for Sustainability National Implementation Group (2016). *Vision 2030+ Concluding report of the Learning for Sustainability National Implementation Group March 2016*. Retrieved from https://education.gov. scot/improvement/ Documents/res1-vision-2030.pdf

Ledoux, G., Meijer, J., Veen, L. Van der, Breetvelt, I., Dam, M. & Volman, M. (2013). *Meetinstrumenten voor sociale competenties, metacognitie en advanced skills. Een inventarisatie*. Rapport 900. Amsterdam, Netherlands: Kohnstamm Instituut.

Lemke, C., Coughlin, E., Thadani, V. & Martin, C. (2003). *enGauge 21st century skills. Literacy in the digital age*. North Central Regional Educational Laboratory / Metiri Group. Retrieved from https://pict.sdsu.edu/engauge21st.pdf

Levin, K., Cashore, B., Bernstein, S. & Auld, G. (2012). Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. *Policy Sciences*, 45(2), 123-152.

Lewis, A. & Smith, D. (1993). Defining higher order thinking. *Theory Into Practice*, 32(3), 131-137.

Limón, M. (2001). On the cognitive conflict as an instructional strategy for conceptual change: A critical appraisal. *Learning and Instruction*, 11(4), 357-380.

Lincoln, Y. & Guba, E. (1985). *Naturalistic Inquiry*. London, UK: SAGE Publications.

Litman, J. (2005). Curiosity and the pleasures of learning: Wanting and liking new information. *Cognition and Emotion*, 19(6), 793-814.

Littledyke, M. (2004). Primary children's views on science and environmental issues: examples of environmental cognitive and moral development. *Environmental Education Research*, 10(2), 217-235.

Livingston, K., Schweisfurth, M., Brace, G. & Nash, M. (2017). *Why Pedagogy Matters: The role of pedagogy in Education 2030. A policy advice paper, May 2017*. Retrieved from *https://www.unesco.org.uk/wp-content/uploads/2017/06/pedagogy.pdf*

Lo Iacono, V., Symonds, P. & Brown, D.H.K. (2016). Skype as a Tool for Qualitative Research Interviews. *Sociological Research Online*, 21(2), 1-15. doi: 10.5153/sro.3952

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin*, 116(1), 75-98.

Longo, C. (2010). Fostering Creativity or Teaching to the Test? Implications of State Testing on the Delivery of Science. *Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 83(2), 54-57.

Lozano, J. F., Boni, A., Peris, J. & Hueso, A. (2012). Competencies in Higher Education: A Critical Analysis from the Capabilities Approach. *Journal of Philosophy of Education*, 46(1), 132-147.

Lozano, R., Merrill, M.Y., Sammalisto, K., Ceulemans, K., Lozano, F.J. (2017). Connecting Competences and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal. *Sustainability*, 9(10), 1889-1904. doi:10.3390/su9101889

Madden, R. (2010). *Being Ethnographic: A Guide to the Theory and Practice of Ethnography*. Los Angeles, CA: SAGE Publications.

Malhi, Y. (2017). The Concept of the Anthropocene. *Annual Review of Environment and Resources*, 42, 77-104.

Malone, K., Truong, S. & Gray, T. (Eds.) (2017). *Reimaging Sustainability in Precarious Times*. Amsterdam, Netherlands: Springer.

Mannion, G. (2005). Borderland Voices and Practices: The Ambiguity of Children’s Participation in School Grounds Greening. *Canadian Journal of Environmental Education*, 10(1), 241-255.

Mason, L. (1996). An analysis of children's construction of new knowledge through their use of reasoning and arguing in classroom discussions. *International Journal of Qualitative Studies in Education*, 9(4), 411-433, doi: 10.1080/095 1839960090404

Mayer, M. & Tschapka, J. (Eds.) (2008). *Engaging youth in sustainable development. Learning and teaching sustainable development in Lower Secondary Schools*, Council of Europe, May 2008.

McDowall, S. & Hipkins, R. (2018). *How the key competencies evolved over time: Insights from the research*. Wellington, New Zealand: New Zealand Council for Educational Research.

McNaughton, M. (2009). Closing in on the picture: Analyzing Interactions in Video Recordings. *International Journal of Qualitative Methods*, 8(4), 27-48.

McNaughton, M. (2014). From Acting to Action: Developing Global Citizenship Through Global Storylines Drama. *The Journal of Environmental Education*, 45(1), 16-36.

McNiff, J. (2013). *Action Research: Principles and practice* (3rd ed.). Abingdon, UK: Routledge.

Mercer, N. & Sams, C. (2006). Teaching children how to use language to solve maths problems. *Language and Education*, 20(6), 507-528.

Mercer, N. & Littleton, K. (2007). Dialogue and the Development of Children's Thinking. A sociocultural approach. London: Routledge.

Mercer, N. (2010). The analysis of classroom talk: Methods and methodologies. British Journal of Educational Psychology, 80(1), 1-14.

Merriam, S.B. & Tisdell, E.J. (2016). *Qualitative Research: A Guide to Design and Implementation* (4th ed.) [Adobe Digital Editions]. San Francisco, CA: John Wiley & Sons.

Merrian-Webster. (n.d.). Intuition. Retrieved from https://www.merrian-webster.com/dictionary/intuition

Metzger, M. & Flanagin, A. (2013). Credibility and trust of information in online environments: The use of cognitive heuristics. *Journal of Pragmatics*, 59, Part B, 210-220.

Meyer, J. & Land, R. (2005). Threshold concepts and troublesome knowledge (2): epistemological considerations and a conceptual framework for teaching and learning. *Higher Education: The International Journal of Higher Education and Educational Planning*, 49(3), 373-388.

Miles, M.B. & Huberman, A.M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Milton, J. (2013). Measuring the contribution of vocabulary knowledge to proficiency in the four skills. In C. Bardel, C. Lindqvist & B. Laufer (Eds.), *L2 vocabulary acquisition, knowledge and use: New perspectives on assessment and corpus analysis* (pp. 57-78). EUROSLA - the European Second Language Association.

Ministry of Education (2007). *The New Zealand Curriculum for English-medium teaching and learning in years 1-13*. Wellington, New Zealand: Learning Media Limited.

Moafian, F., Pagnini, F. & Khoshsima, K. (2017). Validation of the Persian Version of the Langer Mindfulness Scale. *Frontiers in Psychology*, 8(1), Article 468, 1-9.

Moghadam, S.H., Zainal, Z. & Ghaderpour, M. (2012). A Review on the Important Role of Vocabulary Knowledge in Reading Comprehension Performance. *Procedia - Social and Behavioural Sciences*, 66 (2012), 555-563.

Molnar, D., Morgan, A. & Bell, D. (2001). *Defining Sustainability, Sustainable Development and Sustainable Communities: A working paper for the Sustainable Toronto Project, Final Draft*. York, UK: York Centre for Applied Sustainability.

Moon, T.R., Brighton, C. M., Jarvis, J.M. & Hall, C.J. (2007). *State standardized testing programs: Their effects on teachers and students (RM07228)*. Storrs, CT: University of Connecticut, The National Research Center on the Gifted and Talented.

Moon, J. (2008). *Critical thinking an exploration of theory and practice*. London, UK: Routledge.

Morrison, K. (2008). Educational Philosophy and the Challenge of Complexity Theory. *Educational Philosophy and Theory*, 40(1), 19-34.

Morrow, V. & Richards, M. (1996). The Ethics of Social Research with Children: An Overview. *Children & Society*, 10(2), 90-105.

Morrow, S. (2005). Quality and Trustworthiness in Qualitative Research in Counselling Psychology. *Journal of Counselling Psychology*, 52(2), 250-260.

Monroe, M., Plate, R., Oxarart, A., Bowers, A. & Chaves, W. (2017). Identifying effective climate change education strategies: a systematic review of the research. *Environmental Education Research*, 1-22. doi: 10.1080/13504622.2017.1360842

Moore, C., Bryant, D. & Furrow, D. (1989). Mental terms and the development of certainty. *Child Developmen*t, 60(1), 167-171.

Moore, C., Pure, K. & Furrow, D. (1990). Children's Understanding of the Modal Expression of Speaker Certainty and Uncertainty and Its Relation to the Development of a Representational Theory of Mind. *Child Development*, 61(3), 722-730.

Morcke, A.M., Dornan, T. & Eika, B. (2013). Outcome (competency) based education: an exploration of its origins, theoretical basis, and empirical evidence. *Advances in Health Science Education*, 18(14), 851-863.

Mosher, F. & Heritage, M. (2017). *A Hitchhiker's Guide to Thinking about Literacy, Learning progressions, and Instruction*. CPRE Research Report #RR 2017-2. Philadelphia, PA: Consortium for Policy Research in Education.

Mulder, M. (2016). *Competence for life: a review of developments and perspective for the future: farewell address upon retiring as Professor of Education and Competence Studies at Wageningen University & Research on 20 October 2016*. Wageningen University & Research. doi: http://dx.doi.org/10.18174/393033

Mullen, C. (2011). Facilitating Self-Regulated Learning Using Mentoring Approaches with Doctoral Students. In B. Zimmerman & D. Schunk (Eds.), *Handbook of Self-Regulation of Learning and Performance* (pp. 137-152). New York, NY: Routledge.

Mulnix, J.W. (2012). Thinking Critically about Critical Thinking. *Educational Philosophy and Theory*, 44(5), 464-479.

Mumford, E. (2003). Information Systems Research and the Quest for Certainty. *Journal of the Association for Information Systems*, 4(4), 197-205.

Narcarato, A. & Grando, R. (2014). The role of language in building probabilistic thinking. *Statistics Education Research Journal*, 13(2), 93-103.

National Council of Teachers of English (2014). How standardized tests shape—and limit—student learning: An NCTE policy research brief. *Council Chronicle*, 24(2), 1-3.

Nel, P., Keville, S., Ford, D., McCarney, R., Jeffrey, S., Adams, S. & Uprichard, S. (2008). Close encounters of the uncertain kind: reflections on doing problem-based learning (PBK) for the first time. *Reflective Practice: International and Multidisciplinary Perspectives*, 9(2), 197-206.

New Learning. (n.d.). *Learning activity*. Retrieved from http://newlearningonline.com/learning-by-design/glossary/learning-activity

Nilson, L. B. (2010). *Teaching at its best: A research-based resource for college instructors* (3rd ed.). San Francisco, CA: John Wiley & Sons.

Noble, K. (2013). 8. Education for Sustainability in Primary Schools Humanities and Social Sciences Education. In N. Taylor, F. Quinn & C. Eames (Eds.), *Educating for sustainability in primary schools. Teaching for the Future* (pp. 135-175). Rotterdam, Netherlands: Sense Publishers.

Noble, H. & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence-based nursing*, 18(2), 34-35.

Nurse, K. (2006). Culture as the fourth pillar of sustainable development. In: *Small states: economic review and basic statistics*, vol. 11, (pp. 28-40), London, UK: Commonwealth secretariat.

Oates, T. (2003). Key skills/key competencies: Avoiding the pitfalls of current initiatives. In D. Rychen, L. Salganik & M. McLaughlin (Eds.), *Selected contributions to the 2nd DeSeCo symposium* (pp. 171-194). Neuchatel, Switzerland: Swiss Federal Statistical Office.

O'Donoghue, T. (2007). *Planning Your Qualitative Research Project: An introduction to interpretivist research in education*. New York, NY: Routledge.

Ofsted (2012). Optional_lesson_observation_checklist_2012 (Ofsted guidance to inspectors January 2012). Retrieved from https://www.scribd.com/document/260333197/I10-Optional-Lesson-Observation-Checklist-2012

Ojala, M. (2012). Hope and climate change: the importance of hope for environmental engagement among young people. *Environmental Education Research*, 18(5), 625-642. doi: 10.1080/13504622.2011.637157

Orlich, D., Harder, R., Callahan, R., Trevisan, M., Brown, A. & Miller, D. (2013). *Teaching strategies: A guide to effective instruction* (10th ed.). *International edition*. Boston, MA: Wadsworth Cengage Learning.

Omelicheva, M. & Avdeyeva, O. (2008). Teaching with Lecture or Debate? Testing the Effectiveness of Traditional versus Active Learning Methods of Instruction. *Political Science and Politics*, 41(3), 603-607.

O'Neill, D. & Atance, C. (2000). 'Maybe my daddy give me a big piano': The development of children's use of modals to express uncertainty. *First Language*, 20(58), 29-52.

One Planet Schools Working Group (2012). *Learning for sustainability. The report of the One Planet Schools Working Group*.

Oros, A. (2007). Let's Debate: Active Learning Encourages Student Participation and Critical Thinking, *Journal of Political Science Education*, 3(3), 293-311, doi: 10.1080/15512160701558273

Oxford Dictionaries. (n.d.). *Knowledge*. Retrieved on September 16, 2018 from https://en.oxforddictionaries.com/definition/knowledge

Ozturk, O. & Papafragou, A. (2015). The Acquisition of Evidentiality and Source Monitoring. *Language Learning and Development*, 12(2), 199-230.

Ozima, M., Korenaga, J. & Yin, Q. (2012). *The Earth: Its Birth and Growth (2nd ed.)*. Cambridge, UK: Cambridge University Press.

Papafragou, A. (1998). The Acquisition of Modality: Implications for Theories of Semantic Representation. *Mind and Language*, 13(3), 370-399.

Partnership For 21st Century Skills (2009). *P21 Framework Definitions*. Retrieved from http://www.p21.org

Patton, M. (1999). Enhancing the Quality and Credibility of Qualitative Analysis. *Health Services Research*, 34(5 Part II), 1189-208.

Paul, R. (1995). *Critical Thinking. How to prepare students for a rapidly changing world*. Santa Rosa, CA: Foundation for Critical Thinking.

Paul, R. & Elder, L. (2007). *A Guide for Educators to Critical Thinking Competency Standards. Standards, Principles, Performance, Indicators, and Outcomes. With a Critical Thinking Master Rubric. Limited Preview Version*. Tomales, CA: The Foundation for Critical Thinking. Retrieved from www.criticalthinking.org

Paul, R. & Elder, L. (2011). Critical Thinking: Competency Standards Essential for the Cultivation of Intellectual Skills, Part. 2. *Journal of Developmental Education*, 35(1), 36-37.

Peirce, C.S. (author), Hartshorne, C., Weiss, P. & Burks, A. (Eds.) (1931-1958). *The Collected Papers of Charles Sanders Peirce.* Cambridge, MA: Harvard University Press. (Retrieved from https://www.google.co.uk/search?q=1931-1958.+C.+Hartshorne%2C+P.+Weiss%2C+A.+Burks%2C+eds.+Collected+Papers+of+Charles+Sanders+Peirce&ie=utf-8&oe=utf-8#).

Pérez-Parent, M. (2002). Collection, handling, and analysis of classroom recordings data: using the original acoustic signal as the primary source of evidence. *Reading Working Papers in Linguistics*, 6, 245-254.

Perkins, M. & Firth, C. (1991). Production and comprehension of modal expressions by children with a pragmatic disability. *First Language*, 11(33), 416.

Perkins, D. (1999). The many faces of constructivism, *Educational Leadership*, 57(3), 6-11.

Perkins, D. (2014). Future Wise: Educating our children for a changing world. San Francisco, CA: John Wiley & Sons.

Petersen, A. (2002). *The Precautionary Principle, Knowledge Uncertainty, and Environmental Assessment*. Paper for NOB/NIG workshop “Knowledge Uncertainty”, 30-31 October 2002, Erasmus University Rotterdam, 1-19.

Piaget, J. (1952). *The origins of intelligence in children*. New York, NY: International Universities Press, Inc.

Piaget, J. (1954). *The construction of reality in the child*. New York, NY: Basic Books.

Piekny, J. & Maehler, C. (2013). Scientific reasoning in early and middle childhood: The development of domain-general evidence evaluation, experimentation, and hypothesis generation skills. *British Journal of Developmental Psychology*, 31(2), 153-179.

Pikulski, J. & Templeton, S. (2004). Teaching and developing vocabulary: Key to long-term Reading success. *Current research in Reading / Language Arts*. 1-12.

Pine, G. (2009). *Teacher Action Research: Collaborative, Participatory, and Democratic Inquiry. In: Teacher Action Research: Building Knowledge Democracies*. Thousand Oaks, CA: SAGE Publications.

Pirie, S. (1996). *Classroom Video-Recording: When, Why and How Does It Offer a Valuable Data Source for Qualitative Research?* Paper presented at the 18th Annual Meeting of North American Chapter of the International Group for the Psychology of Mathematics Education, Panama City, Florida.

Plutzer, E., McCaffrey, M., Hannah, A.L., Rosenau, J., Berbeco, M. & Reid, A. (2016). Climate confusion among U.S. teachers. *Science,* 351(6274), 664-665.

Polasky, S., Carpenter, S., Folke, C. & Keeler, B. (2011). Decision-making under great uncertainty: environmental management in an era of global change. *Trends in Ecology and Evolution*, 26(8), 398-404.

Prinski, S., Hecht, C. & Harackiewicz, J. (2018). Making Learning Personally Meaningful: A New Framework for Relevance Research. *The Journal of Experimental Education*, 86(1), 11-29.

Probst, B. & Berenson, L. (2014). The double arrow: How qualitative social work researchers use reflexivity. *Qualitative Social Work*, 13(6), 813-827.

Public Schools of North Carolina Foreign Language Project. (1999). *Assessment, Articulation, and Accountability*. Raleigh, NC: Department of Public Instruction.

Quinlan, E. (2008). Conspicuous Invisibility: Shadowing as a Data Collection Strategy. *Qualitative Inquiry*, 14(8), 1480-1499.

Raab, N. (2004). Becoming an Expert in Not Knowing: Reframing Teacher as Consultant. In C. Grey & E. Antonacopoula (Eds.), *Essential Readings in Management Learning* (pp. 255-270). London, UK: SAGE Publications Ltd.

Ramaley, J. (2014). The Changing Role of Higher Education: Learning to Deal with Wicked Problems. *Journal of Higher Education Outreach and Engagement*, 18(3), 7-21.

Ramsey, J.L. (2015). On Not Defining Sustainability. *Journal of Agricultural and Environmental Ethics*, 28(6), 1075-1087.

Rebich, S. & Gautier, C. (2005). Concept Mapping to Reveal Prior Knowledge and Conceptual. *Journal of Geoscience Education*, 53(4), 355-365.

Redclift, M. (2005). Sustainable Development (1987-2005): An Oxymoron Comes of Age. *Sustainable Development*, 13 (4), 212-227.

Reichertz, J. (2007). Abduction: the logic of discovery of Grounded Theory. In A. Bryant & K. Charmaz (Eds.), *The SAGE handbook of Grounded Theory* (pp. 215-228). London, UK: SAGE.

Remmers, T. (2007). *Sustainable development is learning to look ahead. Core Curriculum Learning for Sustainable Development. Basic education 4-16 years of age*, Enschede, Netherlands: SLO.

Remmerswaal, A. & Voerman, K. (2016). *Natuurlijk leren in beeld: Het zichtbaar maken van 21e eeuwse competenties op Democratische basisschool De Vallei*. Wageningen UR, Wetenschapswinkel Rapport 325.’s-Hertogenbosch, Netherlands: RICOH.

Richards, J. & Farrell, T. (2011). *Practice Teaching: A Reflective Approach*. Cambridge, UK: Cambridge University Press.

Rieckmann, M. (2012). Future-oriented higher education: Which key competencies should be fostered through university teaching and learning? *Futures*, 44(2), 127-135.

Ritchey, T. (2011). *Wicked Problems – Social Messes: Decision Support Modelling with Morphological Analysis*, Volume 17, Risk, Governance and Society. Heidelberg, Germany: Springer.

Ritchey, T. (2013). Wicked Problems: Modelling Social Messes with Morphological Analysis. *Acta Morphologica Generalis*, 2(1), 1-8.

Ritchhart, R. & Perkins, D. (2000). Life in the Mindful Classroom: Nurturing the Disposition of Mindfulness. *Journal of Social Issues*. 56(1), 27-47.

Ritchhart, R. & Perkins, D. (2008). Making Thinking Visible. *Educational Leadership*, 65(5), 57-61.

Rittel, H. & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155-169.

Rodríguez, M., Kohen, R. & Delval, J. (2015). Children's and adolescents' thoughts on pollution: cognitive abilities required to understand environmental systems. *Environmental Education Research*, 21(1), 76-91.

Rondamb (2014). Build your brain with critical thinking. *Educational Articles*, 1-5. Retrieved from https://globaldigitalcitizen.org/the-importance-of-teaching-critical-thinking

Rosen, N., Ivanova, E. & Knäuper, B. (2014). Differentiating intolerance of uncertainty from three related but distinct constructs. *Anxiety, Stress & Coping: An International Journal*, 27(1), 55-73.

Rudduck, J. (1988). Changing the world of the classroom by understanding it: A review of some aspects of the work of Lawrence Stenhouse. *Journal of Curriculum and Supervision*, 4(1), 30-42.

Ryan, G. & Bernard, H. (2000). Data management and analysis methods. In N. Denzin & Y. Lincoln (Eds.), *Handbook of Qualitative Research* (2nd ed.) (pp. 769-802). Thousand Oaks, CA: SAGE Publications.

Rychen, D. & Salganik, L. (2003). A holistic model of competence. In: Rychen, D. & Salganik, L. (Eds.), *Key Competencies for a Successful Life and Well-Functioning Society* (pp. 41-62). Cambridge, MA: Hogrefe & Huber.

Saldaña, J. (2016). *The Coding Manual for Qualitative Researchers*. Los Angeles, CA: SAGE Publications.

Savery, J.R. (2006). Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1), 9-20.

Schulz, L. & Bonawitz, E.B. (2007). Serious Fun: Preschoolers Engage in More Exploratory Play When Evidence Is Confounded. *Developmental Psychology*, 43(4), 1045-1050.

Schwandt, T. (2000). Chapter 7 Three epistemological stances for qualitative inquiry: interpretivism, hermeneutics, and social constructionism. In N. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research* (pp. 189-213). Thousand Oaks, CA: SAGE Publications.

Schwandt, T., Lincoln, Y. & Guba, E. (2007). Judging Interpretations: But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. *New Directions for Evaluation*, 2007(114), 11-25.

Schwartz-Shea, P. & Yanow, D. (2012). *Interpretive research design. Concepts and processes*. New York, NY: Routledge.

Scotland, J. (2012). Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive and Critical Research Paradigms. *English Language Teaching*, 5(9), 9-16.

Scott, T. & O'Sullivan, M. (2005). Analyzing Student Search Strategies: Making a Case for Integrating Information Literacy Skills into the Curriculum. *Teacher Librarian*, 33(1), 21-25.

Scottish Executive (2004). *Curriculum for Excellence*. Retrieved from http://www.gov.scot/ Resource/Doc/26800/0023690.pdf

Scottish Government (2013). *Learning for Sustainability*: *The Scottish Government's response to the Report of the One Planet Schools Working Group*. March 2013. Retrieved from *www.gov.scot/resource/0041/00416172.docx*

Seghezzo, L. (2009). The five dimensions of sustainability. *Environmental Politics*, 18(4), 539-556, doi: 10.1080/09644010903063669

Shaw, C., Brady, L. & Davey, C. (2011). *NCB Guidelines for Research with Children and Young People*. London, UK: NCB Research Centre.

Shenton, A. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22(2004), 63-75.

Shephard, K., Rieckmann, M. & Barth, M. (2018). Seeking sustainability competence and capability in the ESD and HESD literature: an international philosophical hermeneutic analysis. *Environmental Education Research*, 1-16. doi: 10.1080/13504622.2018.1490947

Shulman, L.S (2005). Pedagogies of uncertainty. *Liberal Education*, 91(2), 18-25.

Sinclair, A. (2008). Conceptualizing learning for sustainability through environmental assessment: Critical reflections on 15 years of research. *Environmental Impact Assessment Review*, 28(7), 415-428.

SLO & Kennisnet (2016). *Nieuw model 21^e eeuwse vaardigheden*. Retrieved from https://www.kennisnet.nl/artikel/nieuw-model-21e-eeuwse-vaardigheden/

Smith, T.B. (2008). Teaching Vocabulary Expeditiously: Three Keys to Improving Vocabulary Instruction. *The English Journal*, 97(4), 20-25.

Sobel, D. (1996). *Beyond Ecophobia: Reclaiming the Heart in Nature Education*. Great Barrington, MA: The Orion Society.

Sorrentino, R., Roney, C. & Hanna, S. (1992). Chapter 92 - Uncertainty orientation. In C. Smith (Ed.), *Motivation and Personality* (pp. 419-427). Cambridge, UK: Cambridge University Press. Retrieved from http://dx.doi.org/10.1017/CBO9780511527937.030

Sorrentino, R. & Roney, C. (2000). *Essays in social psychology: The Uncertain Mind: Individual Differences in Facing the Unknown*. Philadelphia, PA: Psychology Press.

Sorrentino, R., Otsubo, Y., Yasunaga, S., Kouhara, S., Szeto, A. & Nezlek, J. (2003). Uncertainty Orientation and Emotional Responses to Everyday Life Within and Across Cultures. In G. Zheng, K. Leung & J. Adair (Eds.), *Perspectives and Progress in Contemporary Cross-Cultural Psychology* (pp. 295-305). Beijing, China: China Light Industry Press.

Spiteri, J. (2015). *Young Children's Perceptions of Environmental Sustainability: A Maltese Perspective* (Unpublished doctoral dissertation). University of Edinburgh, Edinburgh, UK.

Spiteri, J. (2018). Why We Should Start Early with ESD for Lifelong Learning. In: W. Filho, M. Mifsud & P. Pace (Eds.), *Handbook of Lifelong Learning for Sustainable Development*, World Sustainability Series (pp. 109-128). Cham, Switzerland: Springer International Publishing.

Stake, R.E. (1995). *The art of case study research*. Thousand Oaks, CA: SAGE Publications.

Stake, R.E. (2000). Case studies. In: N. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research* (pp. 435–454). Thousand Oaks, CA: SAGE Publications.

Starko, A. (2010). *Creativity in the Classroom. Schools of Curious Delight* (4th ed.). New York, NY: Routledge.

Stenhouse, L. (1975). *An Introduction to Curriculum Research and Development*. London: Heinemann Educational Books.

Stenhouse, L. (1976). *Teacher Development and Curriculum design*. Norwich: CARE, University of East Anglia.

Sterling, S. (2010). Transformative Learning and Sustainability: Sketching the Conceptual Ground. *Learning and Teaching in Higher Education,* 5, 17-33.

Sternberg, R.J. (1986). *Critical Thinking: Its Nature, Measurement, and Improvement.* Washington D.C.: National Institute of Education.

Sterling, S., Glasser, H., Rieckmann, M. and Warwick, P. (2017). Chapter 10 “More than scaling up”: a critical and practical inquiry into operationalizing sustainability competencies. In P.B. Corcoran, J. Weakland and A.E.J. Wals (Eds.), Envisioning futures for environmental and sustainability education (pp. 153-168). Wageningen: Wageningen Academic Publishers.

Stokhof, H., De Vries, B., Martens, R. & Bastiaens, T. (2017). How to guide effective student questioning: review of teacher guidance in primary education. *Review of Education*, 5(2), 123-165. doi: 10.1002/rev3.3089

Stonewater, J. & Stonewater, B. (1984). Research Currents: Teaching Problem-Solving: Implications from Cognitive Development Research. *AAHE-ERIC Higher Education Research Currents,* 36(6), 7-10.

Strife, S. (2012). Children’s environmental concerns: Expressing ecophobia. *The Journal of Environmental Education*, 43(1), 37-54.

Szeto & Sorrentino (2010). 6 Uncertainty Orientation: Myths, Truths, and the Interface of Motivation and Cognition. In R.M. Arkin, K.C. Oleson & P.J. Carroll (Eds.), *Handbook of the Uncertain Self* (pp. 146-172). New York, NY: Psychology Press.

Tauritz, R.L. (2012a). Chapter 19 How to handle knowledge uncertainty: learning and teaching in times of accelerating change. In A.E.J. Wals & P.B. Corcoran (Eds.), *Learning for Sustainability in times of accelerating change* (pp. 299-316). Wageningen, Netherlands: Wageningen Academic Publishers.

Tauritz, R.L. (2012b). Transforming learning environments and learning tools. In *Conference Proceedings ENSI Conference (March 26th – 28th 2009). 'Creating Learning Environments for the future – Research and Practice on sharing knowledge on ESD'*. Leuven, Belgium: KHL Leuven.

Tauritz, R.L. (2016). A pedagogy for Uncertain Times. In W. Lambrechts & J. Hindson (Eds.), *Research and Innovation in Education for Sustainable Development. Exploring collaborative networks, critical characteristics and evaluation practices* (pp. 90-105). Vienna, Austria: Environment and School Initiatives - ENSI.

Taylor, N., Quinn, F. & Eames, C. (Eds.) (2013). *Educating for Sustainability in Primary Schools. Teaching for the Future*. Rotterdam, Netherlands: Sense Publishers.

Tessier, J. (2009). Classroom Debate Format. *College Teaching*, 57(3), 144-152, doi: 10.3200/CTCH.57.3.144-152

The Pfeiffer Library, Volume 26, (2nd ed.). San Francisco, CA: Jossey-Bass/Pfeiffer. Retrieved from home.snu.edu/~jsmith/library/body/v26.pdf

Thijs, A., Fisser, P. & Van der Hoeven, M (2014). *21^{e} eeuwse vaardigheden in het curriculum van het funderend onderwijs: een conceptueel kader*. Enschede, Netherlands: SLO.

Thomas, I. (2012). *When will the sun go out? And other strange solar system science*. London, UK: Pearson Education.

Thurmond, V. (2001). The Point of Triangulation. *Journal of Nursing Scholarship*, 33(3), 253-258.

Tolle, E. (2016). *A New Earth: Awakening to your life's purpose* (10th Anniversary ed.). London, UK: Penguin books.

Toohey, S. (1999). *Designing courses for higher education*. Buckingham, UK: Society for Research into Higher Education & Open University Press.

Trautmann, S. & Van der Kuilen, G. (2015) 3 Ambiguity Attitudes. In G. Keren & G. Wu (Eds.), *The Wiley-Blackwell handbook of judgement and decision making* (pp. 89-116). Chichester, UK: Wiley-Blackwell.

Trilling, B. & Fadel, C. (2009). *21st Century Skills: Learning for Life in Our Times*. San Francisco, CA: Jossey-Bass.

UNESCO (2014). *Building Inclusive Knowledge Societies: A Review of UNESCO's Action in Implementing the WSIS Outcomes*. Paris, France: UNESCO. Retrieved from unesdoc.unesco.org/images/0022/002264/226425e.pdf

UNESCO (2015). *Rethinking education: towards a global common good?* Paris, France: UNESCO. Retrieved from unesdoc.unesco.org/images/0023/002325/232555e.pdf

UNICEF (2015). *Unless we act now: The impact of climate change on children*. New York, NY: UNICEF. Retrieved from https://www.unicef.org/publications/index_86337.html

Valley, W., Fu, G. & Jovel, E. (2017). Preparing students for complexity and uncertainty: Flexible Learning strategies for developing environmental professionals. In: P.B. Corcoran, J. Weakland & A.E.J. Wals (Eds.), *Envisioning futures for environmental and sustainability education* (pp. 217-228). Wageningen, Netherlands: Wageningen Academic Publishers.

Van Asselt, M. & Vos, E. (2006). The Precautionary Principle and the Uncertainty Paradox. *Journal of Risk Research, 9*(4), 313-336.

Van Asselt, M. (2010). *Perspectives in uncertainty and risk - The PRIMA Approach to decision support*. Boston, MA: Kluwer Academic.

Van Berkel, S., Engelen, R, Van Groen, M, Van Hilte, Wouda, J. & Van Zanden, M. (2013). *Wetenschappelijke verantwoording. Begrijpend luisteren groep 3*. Arnhem, Netherlands: Cito.

Van Bommel, S. (2008). *Understanding experts and expertise in different governance contexts: the case of nature conservation in the Drentsche Aa area in the Netherlands* (Doctoral dissertation). Wageningen University, Wageningen, Netherlands.

Van Gelder, T. (2005). Teaching Critical Thinking: Some Lessons from Cognitive Science. *College Teaching*, 53(1), 41-46.

Van Rossum, E.J. & Hamer, R.N. (2010). *The Meaning of Learning and Knowing* (Doctoral dissertation). Universiteit van Utrecht, Utrecht, Netherlands.

Vaughn, S., Shumm, J. & Sinagub, J. (1996). *Focus group interviews in education and psychology*. Thousand Oaks, CA: SAGE Publications.

Visser, J. & Visser, Y.L. (2004). Ambiguity, cognition, learning, teaching, and design. *TechTrends*, 48(1), 40-43.

Von Renesse, C. & Ecke, V. (2017). Teaching Inquiry with a Lens Toward Curiosity. *PRIMUS*, 27(1), 148-164.

Voogt, J. & Pareja Roblin, N. (2010). *21st Century Skills. Discussienota*. Enschede, Netherlands: Universiteit Twente.

Voogt, J. & Pareja Roblin, N. (2012). A comparative analysis of international frameworks for 21st century competences: implications for national curriculum policies. J*ournal of Curriculum Studies*, 44(3), 299-321.

Wajnryb, R. (1992). *Classroom Observation Tasks: A resource book for language teachers and trainers*. Cambridge, UK: Cambridge University Press.

Wallace, S. (Ed.) (2015). *A Dictionary of Education*. Oxford: Oxford University Press. Retrieved from http://www.oxfordreference.com.ezproxy.is.ed.ac.uk /view/10.1093/acref/9780199679393.001.0001/acref-9780199679393-e-700

Wallace, B.A. & Shapiro, S.L. (2006). Mental Balance and Well-Being: Building Bridges Between Buddhism and Western Psychology. *American Psychologist*, 61(7), 690-701.

Wals, A.E.J. (2003). Exploring pathways to sustainable living: emancipatory environmental education Regional sustainable development reviews. In A. Mather & J. Burden (Eds.), *Encyclopedia of life support systems* (pp. 1-33). Oxford, UK: Eolss Publishers.

Wals, A.E.J. (Ed.) (2007). *Social learning towards a sustainable world: Principles, perspectives, and praxis*. Wageningen, Netherlands: Wageningen Academic Publishers.

Wals, A.E.J., Van der Hoeven, N. & Blanken, H. (2009). *The acoustics of social learning. Designing learning processes that contribute to a more sustainable world*. Wageningen, Netherlands: Wageningen Academic Publishers.

Wals, A.E.J. (2010). *Message in a Bottle: Learning our way out of unsustainability. Inaugural lecture upon taking up the posts of Professor of Social Learning and Sustainable Development, and UNESCO Chair at Wageningen University on May 27th, 2010.* Wageningen, Netherlands: Wageningen University & Research.

Wals, A.E.J. (2012). *Shaping the Education of Tomorrow. 2012 Full-length Report on the UN Decade of Education for Sustainable Development. UNESCO DESD Monitoring & Evaluation 2012*. Paris, France: United Nations Educational.

Wals, A.E.J. & Lenglet, F. (2016). 5 Sustainability Citizen. Collaborative and disruptive social learning. In R. Horne, J. Fien, B. Beza & A. Nelson (Eds.)

Sustainability Citizenship in Cities. Theory and practice (pp. 52-66). London, UK: Earthscan-Routledge.

Wandberg, R. & Rohwer, J. (2010). *Teaching health education in language diverse classrooms*. Burlington, MA: Jones & Bartlett Learning.

Wang, S. (2017). An Exploration into Research on Critical Thinking and Its Cultivation: An Overview. *Theory and Practice in Language Studies*, 7(12), 1266-1280. doi: http://dx.doi.org/10.17507/tpls.0712.14

Welsh, M., Eastwood, M. & D'Agostino, J. (2014). Conceptualizing Teaching to the Test Under Standards-Based Reform. *Applied Measurement in Education*, 27(2), 98-114.

Weinberg, A.M. (1972). Science and Trans-Science. *Minerva*, 10, 209-222.

Wiek, A., Withycombe, L. & Redman, C. (2011). Key competencies in sustainability: a reference framework for academic program development, *Sustainability science*, 6(2), 203-218.

Wiek, A., Bernstein, M., Foley, R., Cohen, M., Forrest, N., Kuzdas, C., Kay, B. & Withycombe Keeler, L. (2015). 16 Operationalising competencies in higher education for sustainable development. In M. Barth, G. Michelsen, M. Rieckmann, I. Thomas (Eds.), *Handbook of Higher Education for Sustainable Development* (pp. 241-260). London, UK: Routledge.

Wilcox, S.A. (1991). *Children's understanding of modal expressions: Understanding the relative certainty of beliefs* (Doctoral dissertation). University of Michigan, Ann Arbor, MI.

Wilding, S. (2012). *Windscape*. Hairmyres, UK: Strident Publishing.

Wilson, P. (1983). *Second-Hand Knowledge. An Inquiry into Cognitive Authority*. Westport, CN: Greenwood.

World Commission on Environment and Development. (1987). *Our common future*. Oxford, UK: Oxford University Press.

Wragg, E.C. & Brown, G. (2001). *Questioning in the primary school*. London, UK: Routledge Falmer.

Wright, T. & Cervetti, G. (2017). A Systematic Review of the Research on Vocabulary Instruction That Impacts Text Comprehension. *Reading Research Quarterly*, 52(2), 203-226.

Yang, M. (2006). A critical review of research on questioning in education: limitations of its positivistic basis. *Asia Pacific Education Review*, 7(2), 195-204.

Yanow, D. (2006). Neither Rigorous nor Objective? Interrogating Criteria for Knowledge Claims in Interpretive Science. In D. Yanow & P. Schwartz-Shea (Eds.), *Interpretation and method: empirical research methods and the interpretive turn* (pp. 67-88). Armonk, NY: M.E. Sharpe.

Yin, R.K. (2009). *Case-study research: design and methods* (4th ed.). Los Angeles, CA: SAGE Publications.

Zalasiewicz, J., Williams, M., Steffen, W. & Crutzen, P. (2010). The New World of the Anthropocene. *Environmental Science & Technology*, 44(7), 228-2231.

Appendix A Project information for parent/guardian

THE UNIVERSITY of EDINBURGH

Learning for Sustainability: A playground for complexity

Research Project Information

My name is Rebekah Tauritz and I am doing my PhD research at the University of Edinburgh. I have always been passionate about Learning for Sustainability. My specific interest is in developing educational strategies that teach children how to manage complex, contradictory environmental information in order to help prepare them for our complex and rapidly changing world. Different educational approaches will be compared. Your child is invited to participate in this study because he/she is this year in P6/P7.

The aims of this study

This research will improve our understanding of the abilities, knowledge and attitudes we need when faced with contradictory information about complex environmental issues. I want to find out which of these competences are already being taught in Scottish primary schools and which educational approaches, appear to be most effective for developing them. The research will also shed light on the capabilities teachers need to effectively teach these competences.

Research methods

Primary school children and staff will be observed and interviewed in the period that complex environmental issues are being studied. In consultation with the teacher, classroom observations may be complemented by audio and/or video recordings. Where available, children's reflective diaries may be analysed.

Benefits to children and educators

The study will benefit the participants by developing their knowledge-base regarding effective learning environments for teaching these competences. Knowledge about strategies for teaching these competences could eventually help teachers working with children to develop their skills in managing complex knowledge.

Consent

This study has received the support of the school's Head Teacher and the University of Edinburgh's Moray House School of Education Ethics Committee has approved the procedures. Participation in this study is entirely voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Edinburgh. If you participate, you are free to refuse to answer any question or to withdraw yourself at any time without consequence.

Privacy and confidentiality

All information collected during the project will be treated confidentially. No names of children or staff will be used in any written publication, report or presentation concerning this study. All names and identifying characteristics will be changed so that no person or school that took part in the project can be recognised. Research records will be stored securely and only I will have access to them. Children and staff will have access to their own data on request. Results will be disseminated through articles in professional and academic journals and through presentations at conferences and for schools. A summary of the findings is provided to participants on request.

If you would like any further information about this research project, please do not hesitate to contact me. If you agree to participate, please sign the consent form and return it to me.

Appendix B Consent form parent/guardian

THE UNIVERSITY *of* EDINBURGH

Parent's / Guardian's Consent Form

Learning for Sustainability: A playground for complexity

My name is Rebekah Tauritz and I am doing my PhD research at the University of Edinburgh. I am investigating the effectiveness of strategies for teaching children how to manage complex, contradictory information. I am asking permission for your child's participation in this study and for using anonymised images of your child in educational publications, reports and presentations. Please read the Project information sheet for more information. If you have any questions, feel free to contact me by sending an e-mail to: r.l.tauritz@sms.ed.ac.uk

I ____ (name of parent / guardian) give my permission for ____________________________________ (child's name) to take part in this study.

Please tick the boxes for those recordings that you are happy for me to use during this research:

Voice-recordings	
Photos	
Video-recordings	

Date: ______________________________

Signature: ___________________________

Please, return this form to your son's or daughter's teacher as soon as possible.

Appendix C Case studies: The five classrooms

Classroom A (P7) - Global warming

Approximately 351 children attended this non-denominational school with classes ranging from Nursery to Primary 1 to 7. The catchment area consisted of a town in the Scottish Borders plus several outlying villages and farms. The school sits on the outskirts of the town centre. The teacher had been teaching for 18 years, usually teaching P6 classes.

This year she was teaching her first P7 class with 28 children. The teacher expressed a definite interest in teaching environmental education, but acknowledged that she did not feel confident about teaching complex sustainability topics. She also commented that it was hard to find enough time for these topics because of the already packed curriculum. Still she chose to give a lesson about global warming.

The observed lesson took place on January 13th 2016 from 11am-12pm. The learning objectives were for the children to gain some knowledge about global warming and be able to link the global issue to local experiences. The teacher began the lesson by asking the children to list which issues were damaging our planet. The children were seated in small discussion groups of approximately four children each. Each group got a large piece of paper and a stack of post-its to write on. The teacher asked the children to give an example to share with the whole class. Then they discussed in their groups for about ten minutes. The teacher walked around answering questions, listening to the discussions and encouraging the children to come up with good examples. She emphasised the use of particular phrases, such as *deforestation*, *the issue of carbon dioxide* and *renewable energy*.

After this the children were asked, within their groups, to choose six issues that were causing the planet the most damage, and to order these issues from the most important to the least important. They got about ten minutes for this exercise. The teacher walked around as before.

After this the teacher addressed the whole class again. She asked each group in turn to relate their most important and their least important issue. Some of the most important issues according to the children were: animals getting hurt because of plastic bags, global warming, CO_2 levels rising due to burning fossil fuels, oil spillages' (killing fish), running out of fossil fuels and therefore needing renewable energy, and damage to land and property because of war. When each group had had its turn, the teacher stated that prior to the lesson she had had to guess which topic the children would pick as the most important issue. She said she was a bit surprised by what the children were saying, as she thought they would all choose global warming.

She then showed the children a PowerPoint about global warming that she had found on a website where teachers share teaching materials that they have made themselves with other teachers.

After this the children once again set out in their small groups to answer a question posed by the teacher: What can we do to try and solve some of these problems? The children thought about solutions to all the different problems they had discussed earlier, so not only those related to global warming. The teacher walked around again, assisting the children in their groups.

After about ten minutes the teacher asked each group to choose their four best ideas. The teacher waited a bit longer before requesting the children's attention for a final classroom discussion. Each group was asked to present their four best ideas. The lesson ended just before lunch break.

Case B (P6) - Is building dams a good or a bad thing?

Approximately 551 children attended this non-denominational school with classes ranging from Nursery to Primary 1 to Primary 7. There are also groups for children with additional support needs. The catchment area consisted of a town in the Falkirk council as well as surrounding villages. The school is an Eco-School; every three years the school does a project about Global citizenship, discussing rights and responsibilities and comparing the Scottish lifestyle with that of others across the world. The teacher had been teaching for eight and a half years, all at the same school. This year's P6 class was her first. She had never taught a P7 class.

This year she was teaching a P6 class with 30 children. The teacher expressed an interest in teaching sustainability topics. For the second year in a row she has attended a Global Storyline course organised by the Falkirk council. She said she enjoyed drama lessons a lot and she was very enthusiastic about the global storylines because of the children's enthusiasm and how the storylines seemed to stimulate learning in the classroom. She worked together with her colleague, who was also teaching a P6 class, to develop learning activities that were not described in the official lesson plan. Although I observed three lessons, in the end only the second lesson was of use, as it was the only one that actively dealt with a complex issue and was centred on dealing with contradictory information, in this case concerning the pros and cons of building dams.

The observed lesson took place on March 3rd 2016 from 1-3pm. The learning objectives were: to develop knowledge about what dams are and what their purpose is, to explore the advantages and the disadvantages of dams, and to be able to hold a debate about the pros and cons of dams. The teacher started by showing the children information about dams on the American Science Trek website. This website introduces science topics to primary-age schoolchildren by providing free teaching materials for teachers and parents. During this activity the teacher asked some questions to check for understanding and find out what prior knowledge the children had about dams.

The second learning activity involved watching a video about advantages and disadvantages of the Katse dam being constructed in Lesotho. After this the children discussed in small groups what new things about dams they had learned during the first two activities. After a few minutes the teacher addressed the whole class again. She talked to the children about the video and asked them about their personal attitude towards water as a resource.

The teacher then announced that for the next activity some children were going to the other P6 classroom and some of the children from that class would come to their classroom. The class next door was also learning about dams. However, by swapping some children one teacher could focus on teaching just about the disadvantages of dams while the other teacher could focus on the advantages of dams. When the children later returned to their own classrooms, they would represent the arguments, for or against dams, opposing the arguments their own class had prepared.

In the class I was observing, the next activity entailed the teacher reading a prepared script describing the disadvantages of dams. The children listened carefully and, as instructed, wrote keywords and key phrases down on a small white board about the things they thought were really important. When the teacher was done reading she told the class that they were going to tally mark those who were for and those who were against dams and compare the outcome with the children's personal opinions after the debate. (Unfortunately, the teacher forgot to do this before the debate.)

Next the teacher asked the children to work together in their small groups and make a poster (A3) containing the information they had each written down on their own white boards. After twenty minutes the children from the other classroom went back to their own classroom and the children from the classroom I was observing who had been next door came back.

The teacher then changed the seating arrangement of the room so that the pro-dam group children were on one side and the against-dam children were on the other side. The teacher explained that her role would be to indicate the next speaker and regain order if necessary. The central question of the debate was: Are dams good or bad (for our environment)? The teacher also asked the children if they remembered some of the polite debating phrases they had learned during their last debate, such as *I can see where you are coming from, but I think…*, *I understand what you are saying, but…* and *I agree with… because…*. Lastly, the teacher asked each child to speak at least once during the debate. Some of the children were very eager to speak and even though it was the end of the school day there were lots of sighs of disappointment when the teacher finally announced the last speakers in the debate. Some children wanted to continue. Before the children left the classroom to go home, they all put their tally marks on the board indicating their own opinions after the debate.

Classroom C (p7) – Renewable energy / When will the sun die? / Why are birds important

This primary school is the same as in Classroom A (see description above). The teacher had been teaching for 25 years, most of them at this school with a few years as a supply teacher elsewhere. She had taught P6 and P7 classes for about seven years. Her colleague from classroom A had suggested that she might also be willing to participate in my study and she was.

This year she was teaching a P7 class with 28 children. We agreed that she would give three lessons that I would observe. The lessons were going to be part of the science topic they were working on that term. In a pre-lesson she had asked the children to help choose the topic and they had decided on 'renewable energy and its growing importance in Scotland and beyond'. The observed lessons took place on the April 28th, May 5th and May 10th 2016. The lessons were each one hour. The children continued with the topic, presenting their work after my observations.

Lesson 1

The learning objective of the first lesson was to learn to identify a complex scientific issue, in this case renewable energy in general and wind energy in particular, and be able to discuss the principal ideas. The teacher started the lesson by asking the children if they still remembered the pre-lesson and the three topics they had considered. She gave the children a minute to quickly recap in small groups and to remember that they had chosen the topic about wind turbines after which there was a short classroom discussion. She then asked the children if people sometimes disagreed concerning the issue of wind farms and wind energy, and if this could be called a controversial topic. She also asked them what could bring disagreeing people together and lead to a solution. They talked about this in a classroom discussion.

Next the children were asked to work in small groups. Each group got a sheet with statements on it about wind energy and they had to sort the statements into advantages and disadvantages. The group was asked to designate a reader and a reporter. The teacher walked around answering questions and listening to the discussions.

Statements:

Wind turbines can be seen from long distances, and some people do not like the way they look. Wind power does not cause climate change or pollution.

The land underneath wind turbines can still be used for farming. The wind does not always blow across the whole of the UK all of the time.

Wind is a renewable resource as long as the wind blows it will never run out. Wind energy is a cheap way to produce renewable energy.

After about seven minutes the teacher addressed the whole class and asked the reporter from each group to say whether a particular statement was an advantage or a disadvantage. A discussion ensued about whether the sun was a renewable energy source or not (as it will die eventually). The children seemed more engaged by this question than anything up until this point. The children came up with several interesting questions and the teacher encouraged them to write them down so that they could come back to them later.

After an interesting discussion about *science* and *knowing things for sure* the teacher introduced a BBC Bitesize KS2 video: How useful are wind turbines? The teacher then asked the children to discuss the idea of putting wind turbines out to sea. After a minute the teacher told them they were going to watch the video again. While watching, they were to keep two statements in mind that were on the sheet the children had received (see in the box below). After the video they discussed the statements in their groups for five minutes. The teacher walked around answering questions and listening to the discussions.

Sheet with questions to complement the BBC Bitesize video: How useful are wind turbines?

Do you agree or disagree with these statements?

1. Wind turbines are probably the best renewable energy source at present.

2. Wind turbines are ugly to look at and noisy.

Who said this? How do we know this is true? How could we find out?

3. Wind turbines are proven to be a very effective way of producing energy.

Discuss your thought and ideas in your group. You have 5 minutes.

Next the groups were asked to report back to the whole class what they thought about putting turbines out at sea. A discussion about wind turbines evolved into an emotional discussion about the importance of birds. This was a direct result of one of the small groups talking about how birds die by colliding with windmills and sharing this in the classroom discussion. One boy shocked the classroom when he asked in a cold and unemotional way why anybody cared what happened to birds. He then asked: *What have birds every done for the world?* After a while the teacher said they would come back to the discussion about birds, but for now they were to focus on the turbines. The children had to consider within their groups who could have made the statements, as well as consider how they could know whether or not the statements were true and how they could find out if they weren't sure. A classroom discussion followed.

After this they watched another BBC Bitesize KS2 video: Green energy – wind and solar power. In the last five minutes of the lesson each group received one more question to talk about (from the five in the box below). Each group got a different question. The teacher walked around answering and asking questions, and listening to the discussions. The children wrote down their group's answer. Then it was time for lunch and the lesson ended.

Sheet with questions to complement the BBC Bitesize video: Green energy – wind and solar power

1. Why do some people dislike them so much?
2. What do you think would be good solutions to this problem?
3. Could each house have a small colourful wind turbine?
4. Is the sea option the best?
5. Create a persuasive argument for the best options to this problem.

Note down any other questions you have about wind turbines on the opposite page.

Lesson 2

The learning objective of the second lesson was to learn how to conduct research and discuss a complex scientific issue, in this case the role of birds in our world, and how the sun will die, and to be able to discuss these, as well as listen to and share opinions. The teacher started the lesson by telling the children that they were going to pursue two questions that came up during the last lesson: *What do birds do for the world?* and *How will the sun die?* She then told the children that she wanted them to think about what they already knew and to write this down on a sheet of paper (folded in order to create 6 boxes). When the children were done writing down what they knew they were encouraged to *magpie* which means they walked around talking to their peers and collecting some of their ideas. The teacher walked around answering and asking questions and listening to the discussions. After this the teacher addressed the whole class again and they discussed the different facts and questions the children had written down about *the birds* and *the sun*. Then they watched a short video about *how the sun will die* followed by an animated classroom discussion. The teacher then told the children to talk about the fate of the sun and the consequences for humans in small groups. The teacher walked around and talked to children individually or in small groups.

For the last 25 minutes the teacher divided the class in half. One group continued with the questions about the sun and the other group looked into the question of what bird's do for the world. The children who continued with the sun got a book and the children who would be focusing on the birds got a laptop. The bird group then watched a video about a young, passionate ornithologist who shared her ideas about the importance of birds. After the video the teacher talked with all the groups of children investigating the birds. One of the items discussed was the role of birds as indicator species. For the last ten minutes of the lesson the teacher gave each of the six bird groups a statement that they were supposed to read and discuss within their group. The statements represented different people's ideas about the reason why birds are important. The children were asked to decide if they agreed with the opinion or not, and if the statement raised any questions. The teacher walked around assisting the children. The lesson ended with a brief classroom discussion during which a few children shared some of the things they found out during their research.

Lesson 3

The learning objective of the third lesson was to learn to research and discuss a complex scientific issue, in this case the role of birds in our world, and how the sun will die, and be able to discuss these issues, backing opinions up with evidence from scientists and justifying the selected information they put in a presentation. The teacher started the lesson by asking the children what they talked about during the last lesson. Before splitting the class up in small groups, they watched a short video about fossil fuels (from www.tigtagworld.co.uk) and did a *true or false quiz,* followed by another TigTag video *The sun as our main source of energy*. The latter discussed that fossil fuels came from the sun hundreds of millions of years ago.

The teacher asked the children why she showed the video and asked them how it was relevant in relation to last week's topic of the dying sun. The children were told to discuss this question with their neighbour. The teacher walked around assisting the children, asking and answering questions. After a few minutes she addressed the class again and in a classroom discussion they talked about the importance of fossil fuels for humans. Then the class was split up in the small groups of two or three children formed during the second lesson. The teacher divided the notebook computers and organised where the groups were seated. She handed the children a new sheet with questions. Each group was asked to choose one or two questions and investigate them, making a PowerPoint or a poster explaining what they found. They were also allowed to choose their own related question.

The big questions on the sheet:

1. Will the Sun's energy last forever?
2. What will happen to the Earth?
3. Where does the Sun's energy come from?
4. When will the Sun go out?
5. Can we survive without Sun?

(The teacher said that questions 2 and 5 were the most popular.**)**

---

1. What do birds do for the world?
2. Why are birds important?

The teacher walked around assisting the children, asking and answering questions. Some children were quite focused on their PowerPoints, other discussions drifted off for a while. The teacher occasionally addressed the whole class to share some tips about finding information online. In general, the children worked independently and were encouraged by the teacher to do so. The teacher told me that this was very relevant considering their stage in their primary school career. At the end of the lesson the teacher told them to save everything before going off to have lunch.

Classroom D (p6) – Beaver reintroduction

Approximately 415 children attended this non-denominational school with classes ranging from Nursery to Primary 1 to Primary 7. The catchment area consisted of a town in West Lothian. The teacher had been teaching for six years. He had taught P6 classes for four years but no P7 classes. This year he was teaching a P6 class with 31 children.

The observed lesson took place on the 25th of May 2016 from 13:15-15:00. It was part of a topic about Scotland. The class had had a visit from an employee of the Scottish Parliament earlier that week. They talked about the responsibilities of the parliament and which matters were decided upon by the UK government and which were the devolved matters that were decided upon by the Scottish government. They also learned about the rules and format of a parliamentary debate and experienced what it was like while debating about wolf reintroduction in Scotland. I was introduced to the children before the lunch break. During the break I discussed with the teacher how the tables would be arranged so that I could arrange the recorders around the room. Unfortunately, the teacher did some things differently, so that the recorders were not always optimally placed.

The learning objectives were to learn to use print and online sources to understand a controversial topic, to use information to back or refute arguments and to learn skills relevant to listening to and using persuasive language. The topic of the debate this time was the reintroduction of beavers in Scotland. The teacher started the lesson by gathering the children together on the carpet in front of the smart board and recapping with the children what had happened during the guest lesson about the Scottish parliament. After this he introduced the new topic about beaver reintroduction. The teacher and the children talked about what the children already knew about beavers and then the teacher used a PowerPoint presentation from the website of the Scottish Beaver Trial to introduce some more facts about beavers, ensuring that all the children had some basic knowledge about these mammals before entering into the debate.

The next learning activity involved conducting teacher-led research. The teacher talked to the children about the different groups of actors who would be affected by the outcome of the trial. The class was divided into 14 pairs, each representing a societal group either for or against reintroduction of beavers. Each pair got a work sheet with space to write down arguments for and against beaver reintroduction and several information sheets. Some of the sheets contained the outcomes from the Beaver trial, for example, regarding the effects on bird or fish populations. The children had to consider which groups would be for and which groups would be against beaver introduction. The children had to find arguments to back their group's opinion. The teacher also mentioned a couple of websites that they could use for additional information. Although the children really wanted to use the laptops to get on internet, their internet access was frustratingly slow. The teacher walked around answering the children's questions. This activity took about twenty minutes. Half-way through the teacher reminded the children that they had to have evidence to back up their claims. At the end of this activity the teacher organised the set-up of the classroom for the debate.

One boy who had been given the role of presiding officer sat at the front of the class behind a desk. The other children were grouped around him in a few rows. The recorders were taken to the debate. Some children put them on the ground, while others picked them up and held them so that they would most clearly record what the children nearest to it were saying. Some children seemed to take it more seriously than others who made silly remarks. The children often laughed and enjoyed shouting *Objection!* Sometimes the teacher and sometimes the presiding officer silenced them. At the end of the debate the children voted for or against the motion of reintroducing beavers. This time they were allowed to make up their own minds and were not bound by the perspectives of the group they had represented earlier. The motion was passed with a very large majority of the children voting for reintroduction.

The teacher then told the children to hand the recorders back to me and to set the tables and chairs back as they had been. When the children sat down a few minutes later the teacher unexpectedly continued with the lesson about the beavers by asking the children what they found out that afternoon. Luckily, the teacher was still wearing his microphone and I quickly started to jot down as much as I could of what I was hearing. The teacher then discussed some other issues in the last minutes before the school bell rang and the children left the classroom.

Classroom E (P7) - Pollinators

Approximately 215 children attended this non-denominational school with classes ranging from Nursery to Primary 1 to Primary 7. The catchment area consisted of an historic town in the Highland council area. After graduating from a primary education programme, this teacher worked in youth and community centres, due to personal circumstances. After moving to Scotland she taught for eight years, five as a supply teacher and as a learning support teacher with additional support needs and three years as a classroom teacher. She had never taught P6 and this was her first P7 class. This year's class consisted of 16 children.

The observed lesson took place on the 16th of June 2016 from 13:30-15:00. It was two weeks before the Summer vacation. In fact, the children had just returned from three days at the High school they would be attending after the vacation and were very excited and distracted because of it. The teacher and the children were also organising the end of the year party in between the lessons. The teacher told me during our preparatory conversation that her lesson would be focused on the contradictory information that was being spread regarding the cause of the large scale dying of bee colonies globally. This topic was related to the Polli:Nation project that the school had signed up for. This project is a UK wide initiative supporting children from 260 schools (primary and secondary) in turning their school grounds and other local walk-to spaces into pollinator friendly habitats. Though I stayed overnight at this teacher's home, I decided not to talk about the lesson before the observation. I was taken totally by surprise when the lesson turned out not to be what we had discussed earlier.

The learning objectives for the observed lesson were to be able to explain that a large proportion of plants need animals and insects for pollination, and to be able to describe the reproductive structure of a flower. The observation was particularly challenging because the children kept shouting and at times the teacher was shouting even louder to be heard. This made it difficult to transcribe the lesson. I met the class before their lunch break when I observed a lesson. After the break the teacher explained to the children that I was researching how well the children would understand the concepts that she was going to teach about. The teacher started out by asking the children to consider what their favourite flower was after which they immediately started talking loudly. After a few minutes the teacher asked some of the children to share their answer with the class. The teacher then asked the children why flowers have different shapes and colours. Although, some children called out *pollination!* the teacher kept trying to get the children to answer that the flowers were part of the plants reproduction process. It was difficult for the teacher to keep the children's attention on the lesson due to the end of the year distractions described above.

The teacher then handed the children an information sheet showing a diagram of a flower and all the different parts and their names. She talked about the female and the male parts and that some flowers are pollinated by the wind, but most are pollinated by insects and birds. She asked what reward the insects and birds get for going to a particular flower and after some silly remarks from the children she gave the answer herself, a reward of nectar. The teacher instructed the children to read in groups of four what it said on the information sheet about adaptation. They got three minutes for reading and after that they had to fill in the answers to questions on the information sheets individually. The teacher walked around the room encouraging children to do the task they were given.

When they were done the teacher addressed the whole class again but was having difficulty making herself heard. She told the children that particular birds and insects act as specialists for particular plant species. The teacher continued talking about bats and moths and the adaptations of nocturnal species. Next the teacher asked the children to do the following task: On the back of the information sheet were pictures of particular flowers on one side and of particular pollinators on the other side of the page. The children had to draw a line between the plant and pollinator that were adapted to each other. They had to work out from the information on the front of the sheet which was which. After about five minutes the teacher addressed the whole class again and together they worked their way down the list.

During the last 15-20 minutes of the lesson the children designed a flower using the information on the information sheet to design it. They got a supply of craft materials. The children were still shouting a lot. The teacher walked around repeating her instructions and answering questions. And the end of the 20 minutes the teacher asked the children to tidy up, which they did half-heartedly. After a few minutes the teacher addressed the whole class again asking children to come to the front of the class and share what kind of flower they made, what adaptions it had and for which pollinator. The children were poorly engaged with the lesson, which seemed related to the intrusive factors described above. Sometimes they listened to each other, but more often the teacher's attempts to keep them focused on the lesson were unsuccessful. After the last children managed to share their creations with the class the lesson was over and the recorders were switched off.

Appendix D Storing the audio recordings

After the observed lessons and focus group and teacher interviews, the recordings were uploaded to the designated space on the university network. All the recordings were labelled. The number of the audio recording made during an observation was made up of thirteen symbols:

1. The first symbol refers to a recording made during a classroom observation: **O**
2. The second symbol refers to which school it was: School **1**, **2**, etc.
3. The third symbol refers to the children's grade: **6** (P6), **7** (P7)
4. The fourth symbol refers to the table the recording was made at (see seating plan): **1**, **2**, **3**, etc. Table 1 is the focus group. The teacher (lapel mic) gets number 9.
5. The fifth symbol refers to who the teacher was: Teacher **A**, **B**, etc.
6. The sixth to the thirteenth symbols indicate when the recording was made: **01** (day of the month), **01** (month), **2016** (year)

A recording taken during an observation at school 1, in grade P7, at table 1, in Teacher A's classroom, on January 13th, 2016 gets as a label: O171A13012016.

The number of the audio recording made during a focus group or teacher interview is made up of twelve symbols:

1. The first symbol refers to a recording made during a focus group interview **F** or an interview with the teacher **I**
2. The second symbol refers to which school it was: School **1**, **2**, etc.
3. The third symbol refers to the children's grade: **6** (P6), **7** (P7)
4. The fourth symbol refers to who the teacher was: Teacher **A**, **B**, etc.
5. The fifth to the twelfth symbols indicate when the recording was made: **01** (day of the month), **01** (month), **2016** (year)

A recording made during an interview with a teacher at School 1, in grade P7, with Teacher A and on January 15th, 2016 gets as a label: I17L01152016

Appendix E Example Observation Grid first version

This is a selection from the 3-page long 'Observation Grid – Teacher' that I tried out during the trial observation.

Questions asked by teacher			
Strategies	**Indicators**	**Tally**	**Classroom observations**
Does the teacher ask key questions?	❖ Teacher asks questions that have more than one right answer.		
Does the teacher ask for factual answers?	❖ Teacher asks questions which can be answered by looking for facts.		
Does the teacher ask for opinions?	❖ Teacher asks questions which can be answered by sharing their own ideas and beliefs.		
Does the teacher ask questions with the right answer in mind?	❖ Teacher replies to answer with: "This is the right answer!" ❖ Teacher replies to answer with: "This is the wrong answer!" ❖ Teacher does not reply to answer with: "That is correct, what else could it be?"		
Does the teacher ask the children to think and reason before answering?	❖ Teacher encourages exploration of the topic before answering.		
Does the teacher ask questions regarding the child's strategy for handling knowledge uncertainty?	❖ Teacher asks how the child will search for information in order to answer the question ❖ Teacher asks: "What else could you do to find an answer?"		
Does the teacher ask questions regarding the group process and finding answers?	❖ Teacher asks: "Did you (the group) arrive at an answer and if yes, how did you do it?"		
Does the teacher model question certainty?	❖ Teacher asks: "Are you sure about that?" ❖ Teacher asks: "Can we be certain about the reliability of this source?"		

Appendix F Example Observation Grid second version

This is a selection from the 3-page long 'Observation Grid – Teacher' that I adapted in response to my experience during the trial observation. Although, it was certainly easier to work with it was still not a practical observation tool as it was still too elaborate.

Questions asked by teacher		
Strategies	**Tally**	**Observations**
Teacher asks key questions		
Teacher asks for factual answers		
Teacher asks for opinions		
Teacher asks questions with the right answer in mind		
Teacher asks the children to think and reason before answering		
Teacher asks questions regarding the child's strategy for handling knowledge uncertainty		
Teacher asks questions regarding the group process and finding answers		
Teacher models questioning certainty		

Appendix G Initial Questionnaire - Focus Group Interview

Introduction:

I introduce myself and refer to the day that I was in the classroom doing my observation. I explain that I will be asking some questions about the lesson regarding environmental issues that I observed. I ask the children to write their name on a post-it and stick it on the table in front of them. I then tell the children that I want to hear about their ideas and experiences. I ask them to remain silent while others speak. I emphasize that they do not have to agree with each other and that I will not grade their answers.

1. Could you tell me what the lesson was about?
2. Was there anything confusing about the lesson?
3. If the answer to two is *no*, give them an observed example of a moment where they were confronted with complex, contradictory information and ask them to reflect on that.
4. Did you do anything about it [the confusion]?
5. And if the answer to four is *yes* ask them what they did?
6. How did you feel about that?
7. What did you learn from this lesson? If the children only mention facts about the topic, ask them if they learned anything else.
8. Give the children an example of contradictory information and ask them how they would decide whose experts to believe? If they need prompting, ask them if they learned anything in the lesson that might help.

In the village of Brigadoon villagers are arguing about the proposed waste incinerator that would be placed just outside the village boundaries. The incinerator would help solve the issue of accumulating rubbish due to the growing numbers of people living in Brigadoon. One group of experts says that burning waste will cause air pollution and will affect everyone badly, and especially children with asthma and older people. Some doctors agree that going ahead with this plan would be very bad. However, some don't agree. They say that the incinerator will make use of modern processes that don't allow any harmful substances to be released into the environment. How would you find out which experts you would believe?

Wrapping up:

I tell the children that we have almost ran out of time and that I will repeat the main points from their responses. After this I thank them for talking with me and tell them that their answers are very important for my research and it has helped me a lot. Their answers will help me understand how they experience lessons about complex environmental issues and how we can improve them. I finish up by asking the children if they have something that they would like to ask me. I then escort the children back to their classroom and thank the teacher.

Appendix H Initial Questionnaire - Teacher interview

1. How do you feel the lesson(s) went?
2. How would you describe your teaching strategy?
3. Do you use this teaching strategy/approach more often?
4. How do you think the children managed the (decision regarding the) contradictory information?
5. What adaptations have you made (if at all) to scaffold the complexity of the topic for individual children?
6. In case of relevant objectives mentioned in the lesson plan or in the conversation before the start of the lessons, did you achieve them?
7. How would you describe in a progress report what the children learned in the lesson(s)?
8. Could you explain/interpret particular observations of children's behaviour/responses?

Appendix I Coding Framework - Teacher & Teaching strategy

	Category 1: Prerequisite for uncertainty in the learning process	
	Characteristics learning environment	**Observations**
1	Teacher is open and willing to accept and make use of the concept of uncertainty[18]	

	Category 2: Allowing uncertainty into the learning process	
	Characteristics learning environment	**Observations**
2	Teaching approach is process-oriented	
3	Teacher employs a dynamic and emergent curriculum[19]	
4	Teacher employs inter-disciplinary/holistic topics	
5	Teacher employs an inquiry-based education approach[20]	
6	Teacher scaffolds a change in uncertainty related to individual student level[21]	
7	Teachers and children reverse roles	
8	Teacher exposes children to contradictory or multiple perspectives	
9	Children are stimulated to clarify, elaborate, extrapolate and/or explain their ideas[22]	

[18] For example, a teacher acknowledges different views about man-made global warming versus a teacher who states that 97% of scientists say that global warming is man-made and therefor there is no need to discuss other views, it might even be considered misleading the children.

[19] For example, a child brings a topic into the classroom, perhaps an accident happened on the way to the school and the teacher decides to use this in her lessons.

[20] “Inquiry-based learning is grounded in the philosophy of John Dewey (as is PBL), who believed that education begins with the curiosity of the learner. Inquiry-based learning is a student-centered, active learning approach focused on questioning, critical thinking, and problem solving. Inquiry-based learning activities begin with a question followed by investigating solutions, creating new knowledge as information is gathered and understood, discussing discoveries and experiences, and reflecting on new-found knowledge” (Savery, 2006, p. 16). In an inquiry-based approach the tutor is both a facilitator of learning (encouraging/expecting higher-order thinking) and a provider of information.

[21] A teacher might challenge a child who can handle more knowledge uncertainty by talking (more) about contradictory information, whereas a teacher will, for example, focus more on basic understanding of core concepts with a less able child.

[22] The teacher will ask for more elaboration *after* a child has given a particular answer.

	Category 3: Making uncertainty negotiable in the learning process	
	Characteristics learning environment	**Observations**
10	Contradictory information and viewpoints are discussed explicitly by the teacher with the children	
11	Teacher and children identify and articulate ideas and experiences concerning contradictory information	
12	Teacher employs conditional language[23]	
13	Teacher employs unconditional language[24]	
14	Teacher displays enthusiasm when talking about uncertainty related to contradictory information	
15	Teacher demonstrates different methods that can be used to manage contradictory information	

	Category 4: Instructions versus content	
	Strategies	**Observations**
16	Teacher provides an instructional framework	
17	Teacher provides content information	
18	Teacher connects lessons to the learner's lifeworld	
19	Teacher arouses the learner's curiosity[25]	

[23] Conditional language refers to communicating as if something could be true rather than as if it is true. Langer et al. (1989) state that conditional instruction allows for some uncertainty as "what is generally regarded as a fact represents a probability statement rather than an absolute truth" (p. 141). For example: *Some scientists say that global warming is not man-made.*

[24] Unconditional language refers to communicating as if something is true. For example: *Global warming is man-made*.

[25] The child's curiosity needs to be very obvious, for example, when children go home and check on internet if the teacher was really right about their not being any beavers in Scotland. So one or two questions posed to the teacher is not enough for this code.

	Category 5: Questions asked by teacher	
	Strategies	**Observations**
20	Teacher asks key questions[26]	
21	Teacher asks for factual answers	
22	Teacher asks for opinions	
23	Teacher asks leading questions[27]	
24	Teacher asks the children to think and reason before answering[28]	
25	Teacher asks questions about an individual child's strategy for finding information and arriving at answers	
26	Teacher asks questions about group strategies for finding information and arriving at answers	
27	Teacher models questioning certainty	
69	Teacher answers his or her own question	

	Category 6: Answers and responses given by teacher	
	Teacher strategies	**Observations**
28	Teacher asks: "How did you come to that conclusion about the contradictory information?"	
29	Teacher asks: "What did you think about the topic before you searched for information? What do you think now? Did anything change? If so, what changed?"	
30	Teacher reflects on his/her thinking process out loud.	
31	Teacher points out mistakes and corrects them or uses the error to suggest the next step	
32	Teacher offers reassurance and assistance when child displays distress when confronted with contradictory information	
33	Teacher responds with content or with a strategy to a child's content driven question	
34	Teacher responds with content or a strategy to a child's process driven question	

[26] Key questions are questions with more than one correct answer. They can either be used to access prior knowledge or confront pupils with problems that can be tackled and solved in a number of ways (Bell et al.2007).
[27] Leading questions are questions that are phrased in a manner that tends to suggest the desired answer.
[28] The teacher encourages the children to think closely <u>before</u> (s)he asks the children a question.

	Category 7: Various (Teacher & Teaching Strategy)	
	Strategies	**Observations**
35	Teacher formulates learning objectives regarding learning to manage contradictory information	
36	Teacher does not formulate learning objectives regarding learning to manage contradictory information[29]	
37	Factors that limit a teacher from teaching about a complex, contradictory topic[30]	
38	Factors that promote successful lessons about a complex, contradictory topic[31]	
39	Teacher expresses concern about the environment	
40	Teacher missed opportunity for teaching about complex, contradictory topic.[32]	
41	Teacher's expresses his/her view on quality and availability of educational resources for teaching complex and/or contradictory topics	
67	Teacher limits the confrontation with uncertainty related to contradictory information	
70	Teacher talks about age or developmental stage appropriate level of uncertainty and complexity	

[29] It is not necessary to code every other learning objective; it is especially meant for places where not mentioning any learning objectives regarding managing contradictory information is very apparent.
[30] This is a wide category which includes lack of content knowledge, lack of skills, lack of relevant teaching materials, lack of support from school’s administration, etc.
[31] This is a wide category which includes real-life topics, teacher’s confidence in their teaching skills, support from colleagues, etc.
[32] For example, when teaching materials use conditional language this can be a starting point to talk about that language and what it means about the certainty of knowledge.

Appendix J Coding Framework - Learner & Group

	Category 8: Uncertainty competences: Learning to cherish uncertainty	**Observations**
42	Children respond creatively to the uncertainty of contradictory information[33]	
43	Children are motivated to explore the topic[34]	
44	Children are motivated to find/their own answer[35]	

	Category 9: Uncertainty competences: Learning to tolerate uncertainty	**Observations**
45	Children have beliefs about the uncertainty of contradictory information	
46	Children change their beliefs regarding the uncertainty of contradictory information	
47	Children accept and make use of the uncertainty of contradictory information	
48	Children look over familiar boundaries and are able to find information in fields that are new to them	

	Category 10: Uncertainty competences: Learning to reduce uncertainty	**Observations**
49	Children prioritise among urgent issues[36]	
50	Children find, select and utilise information / Teachers teaches how to find, select and utilise information	
51	Children judge the credibility and cognitive authority of information sources	
52	Children reason	

[33] Instead of feeling insecure of the correct answer, the child takes the lack of one correct answer as an invitation to come with something creative, innovative.

[34] This can refer to a cooperative but rather superficial search for answers amongst the group's prior knowledge, as well as more in-depth search using other information sources.

[35] The child is not giving answers that the teacher would probably want to hear, but comes with more creative and differing ideas. For example, suggesting that humans should stop breathing out to reduce CO_2 levels.

[36] This refers to the steps to be taken during the process of gathering information and making a decision/providing an answer.

53	Children are aware of and respond to underlying probabilities	
54	Children employ previous experience / Teachers build on children's previous experience	
55	Children engage a supportive network[37]	
56	Children formulate a plan of action to manage uncertainty	
57	Children use their intuition as an information source[38]	

	Category 11: Group stuff	**Observations**
58	Children work together to reach a group decision	
59	Children share their opinions and accept other's opinions	

	Category 12: Various (Learner and group)	**Observations**
60	Children find it difficult to make choices regarding complex issues	
61	Children (do not) question certainty of information	
62	Children use unconditional language	
63	Children use conditional language	
64	Children express concern about the environment	
65	Children share their understanding of what the learning objectives of the lesson were	
66	Children display emotion when confronted with uncertainty related to contradictory information	
68	Children or teacher share(s) their ideas about learning uncertainty competences in primary school	
71	Children or teacher talk about children's post lesson feelings, thoughts and or actions regarding the uncertainty surrounding the topic	
72	Children ask factual questions	

[37] This isn't limited to what the children are doing during the observed lesson, but also includes what the children tell in the focus group interview about asking e.g. friends and family for advice with sustainability topics/complex issues.

[38] I am not sure about useful indicators for the use of intuition as an information source.

Appendix K Typology of Questions of Conditionality

	Socratic-based Questions of Conditionality		
	Type of question	**Exemplar questions**	**Uncertainty competences**
1.	Teacher asks child about the understanding of a concept/theory	What could that be?	4
		What could be an example of that?	4
		Could these concepts be described as (dis)similar?	4
		Could these statements be described as contradictory?	4
2.	Teacher probes child's assumptions/beliefs	What are you assuming?	16, 14
		What's the chance that your assumption is true?	16, 5, 13
		What might their assumption be?	17, 13
		What's the chance that their assumption is true?	1, 5, 13
3.	Teacher asks about child's viewpoints	You seem to approach the issue from perspective X, why did you choose that?	17, 4
		What might someone who disagrees say?	17, 4
		What is your opinion on this matter?	17, 4
4.	Teacher probes child's reasoning process	What is your reasoning?	4
		What evidence supports that?	1, 2, 4, 5
		Could we find this out?	19, 14
		What could happen? (speculative)	1, 4
		If this is true, what could the implications be?	1, 4
		If that happens, how might we respond?	18, 19, 7
5.	Teacher asks about a child's strategy for finding information	How could you find out?	19, 1, 7
		Who could you ask?	11, 7
		Where could you find information?	1, 2, 13
		Can we trust this information source?	16, 2, 4

	Uncertainty-based Questions of Conditionality		
	Type of question	**Exemplar questions**	**Uncertainty competences**
6.	Teacher asks about the certainty of information	Do you think this information is (un)certain?	1, 2
		Do you think this knowledge source is (un)certain about this information?	13
		Is this information certain enough to base taking action on?	15, 5
		Is this knowable at this moment?	19, 15, 14
7.	Teacher asks child about feelings regarding not knowing what will happen or what the right answer or action is	How do you feel about not knowing what will happen?	15
		What about not knowing what will happen makes you feel (un)happy/scared/excited?	15
		How do you feel when you don't know which source you can trust?	14
8.	Teacher asks child how to solve a problem	What could be done about that?	19, 20
		How could we solve this problem with what our group already knows about it?	1, 4, 8, 10, 7, 11
		Which issue could we best tackle first?	6, 4, 5
		Could this solution work?	1, 4
		What could your plan of action to solve this issue look like?	7
		Have you come across a similar situation? What happened then?	4, 8
		How could/might we solve the problem with what we learned in the past?	19, 4, 20
		What innovative ideas could we come up with?	18, 19, 20
		Can you come up with something else?	18, 19, 20
		Can you think of something nobody has thought of?	18, 20

Appendix L Teaching strategies employed per classroom

Key elements of the teaching strategy	Learning objectives	Topics	Learning activities	Teaching resources	Language and Questions	Uncertainty Competences
A	To acquire basic knowledge about global warming To be able to link global issues to local experiences	Global warming	Small group discussions (listing and prioritising environmental challenges, and suggesting solutions) Classroom discussions (sharing results of group work with the rest of the class) PowerPoint presentation by the teacher (designed by an unidentified teacher) about global warming	PowerPoint presentation about global warming	Teacher used predominantly unconditional language When facilitating the group work the teacher focused on definitions and phrases related to global warming such as ‘deforestation’ and ‘renewable energy’ Some of the tasks assigned to the small groups were formulated conditionally	Being able to reason Being able to prioritise among many urgent issues Being able to employ previous experience Being able to work in teams with mixed knowledge, skills and experience Being able to interpret what others are communicating about their degree of certainty★ Being able to express one’s own degree of certainty★ Being able to understand people with different perspectives

Key elements of the teaching strategy	Learning objectives	Topics	Learning activities	Teaching resources	Language and Questions	Uncertainty Competences
B	To acquire knowledge of dams and their purpose To know some of the advantages and the disadvantages of dams To be able to hold a debate (about building dams)	Building dams	Classroom discussions (about dams, and about the advantages and disadvantages of dams) Small group discussions (about what new things had been learned about dams) Note taking (either about advantages or disadvantages of dams) Making posters (presenting arguments for or against dams) Classroom debate (to decide if building dams is good or bad)	PowerPoint presentation and video (Science Trek) about advantages and disadvantages of dams	Teacher used a mix of conditional and unconditional language Teacher focused on developing language for talking about advantages and disadvantages of building dams and language used for debating	Being able to find, evaluate and utilise information Being able to reason Being able to respond in accordance with the underlying probabilities Being able to work in teams with mixed knowledge, skills and experience Being able to interpret what others are communicating about their degree of certainty★ Being able to express one's own degree of certainty★ Being able to accept not knowing (what will happen or what the right answer/action is) Being able to understand people with different perspectives

Key elements of the teaching strategy	Learning objectives	Topics	Learning activities	Teaching resources	Language and Questions	Uncertainty Competences
C	To be able to discuss the principal ideas behind the complex scientific issue of renewable energy in general and wind energy in Scotland in particular To be able to participate in group discussions sharing one's thoughts and feelings To be able to back up opinions with scientific evidence	Renewable energy (wind energy) Dying of the sun What birds do for the world	Classroom discussions (about wind energy, dying of the sun, fossil fuels) Conducting research in small groups (about dying of the sun or the role of birds in our world) PowerPoint presentation made by the children of their findings	Worksheets designed by the teacher about wind energy, dying of the sun and importance of birds Videos (Youtube, BBC Bitesize, TigTag)	Teacher used a mixture of unconditional and conditional language, with a focus on the latter Teacher focused on developing language of conditionality (controversy, certainty of knowledge, multiple perspectives) Teacher asked many questions (including a mixture of conditional and unconditional questions) and encouraged the children to ask questions Teacher encouraged the children to be critical of	Being able to find, evaluate and utilise information Being able to judge the credibility and cognitive authority of information sources Being able to conduct research on complex and uncertain topics★ Being able to reason (inductive and deductive reasoning) Being able to respond in accordance with the underlying probabilities Being able to work in teams with mixed knowledge, skills and experience Being able to interpret what others are communicating about their degree of certainty★

					knowledge sources	Being able to express one’s own degree of certainty★ Being able to accept not knowing (what will happen or what the right answer/action is) Being able to reflect on and (potentially) change one’s beliefs regarding uncertainty Being able to understand people with different perspectives Being able to entertain an enquiring mind

Key elements of the teaching strategy	Learning objectives	Topics	Learning activities	Teaching resources	Language and Questions	Uncertainty Competences
D	To be able to use print and online sources to understand a controversial topic To be able to use information to back or refute arguments To develop listening skills and the use of persuasive language Although not specifically mentioned, to acquire knowledge about beavers and ecology was clearly one of the teacher's objectives	Beaver reintroduction	Classroom discussions (about beaver reintroduction and ecology) Conducting research in small groups (about perspectives different involved actors) Parliamentary debate (about beaver reintroduction)	PowerPoint presentation, information sheets about perspectives of different actors, official findings, and a list of pre-selected websites from the Beaver trial Laptops (Internet access was not working properly)	Teacher used predominantly unconditional language Teacher focused on developing language related to beaver reintroduction and ecology, multiple perspectives and language used for debating	Being able to find, evaluate and utilise information Being able to reason Being able to employ previous experience Being able to work in teams with mixed knowledge, skills and experience Being able to interpret what others are communicating about their degree of certainty★ Being able to express one's own degree of certainty★ Being able to understand people with different perspectives

Key elements of the teaching strategy	Learning objectives	Topics	Learning activities	Teaching resources	Language and Questions	Uncertainty Competences
E	To be able to explain that many plants need animals and insects for pollination To be able to describe the reproductive structure of a flower	Pollinators	Classroom discussions (about the function of pollination) Reading information sheets and complementary fill in tasks (about specific pollinators) Crafts (making flowers integrating what they learned about plants' adaptations to specific pollinators)	Worksheets (about pollination and plant reproduction) Craft materials	Teacher used predominantly unconditional language and closed questions Teacher focused on developing language related to pollination and reproductive structure of flowers	Being able to find, evaluate and utilise information