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How can computational thinking be used as a problem-solving methodology to improve the teaching and learning in my classroom?

Caoilinn Tighe

A Research Dissertation submitted to the Froebel Department of Primary and Early Childhood Education, Maynooth University, in fulfilment of the requirements for the degree of Master of Education (Research in Practice)

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Abstract

This thesis explores the question: can Computational Thinking (CT) be used as a problem-solving strategy to improve the teaching and learning in a classroom? The research was conducted using a self-study approach within an action research paradigm to reflect on myself as a professional and the learning taking place in my classroom, with a view to enhancing it. The study took place in a co-educational, rural multigrade 1st/2nd classroom. The epistemological and ontological values underpinning the research and explained throughout are: child-centred approach, perseverance, adaptability and guided discovery. I believe that, as educators, we must focus on the needs of the learners in our classroom and that allowing them time to explore and discuss different topics will aid in the development of important life skills.

Myself and the 1st/2nd class, as co-participants, conducted the research over two cycles. I decided to explicitly teach the 6 different CT concepts before modelling their use with the class. This was done as a means of scaffolding the children's learning experience. The class then participated in challenges to kindle the development of CT. A range of qualitative data was collected throughout both cycles. My reflective journal acted as a means of critical reflection and greatly added to the data collected. Whole class discussions, group interviews and voice recordings provided me with an insight into the children's' learning experience, development and opinions. Through a number of conversations with my critical friends, validation groups and observations from my colleagues, I gained a variety of perspectives on my research and my practice. Ethical standards were followed throughout the research and ethical approval was granted by the school and the University.

The data analysis revealed that the children developed confidence and independence when problem-solving. The children appeared happier and were more efficient with their time. As an educator, I developed a deeper understanding of my values and learned the true benefits of CT.

Having completed the self-study action research process, I have developed a deeper understanding of CT. I have come to appreciate the intrinsic value of creating problem-solving tasks for the children to complete independently. I now understand the benefits of allowing the children agency in group work and independence in the classroom. Throughout this process, I have also deepened my understanding of critical reflection and will continue this practice regularly to further my development as a professional.

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List of abbreviations

CT ……Computational Thinking

CH ……Child

NCCA……..……...National Council for Curriculum and Assessment

DLF ……Digital Learning Framework

ICT ……Information and Communications Technology

DPCF ……Draft Primary Curriculum Framework

PDST……..Professional Development Service for Teachers

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1. Introduction

1.1 Focus and Aims of Study

The ultimate goal of this study was to enhance pupil confidence in problem-solving. Computational thinking (CT) was used as a model problem-solving strategy to aid in the development of the children's and the researcher's problem-solving skills. There are other problem-solving methodologies out there, for example the Kipling Method (1902), but this study is focusing on CT. This study involved the implementation of an action research methodology, through which the researcher reflected upon themselves and designed cycles to enhance their practice and the children's learning experience in their classroom. The research involves two cycles of an integration of CT into daily teachings and follows a basic action research model adapted from Whitehead and McNiff's (2006) action research model. It incorporates a four-step cyclical approach involving reflecting, planning, acting, and observing.

The focus of this research is on myself as a practitioner and how I can enhance my teaching and the learning experience of the children in my class. Upon reflecting on my practice, I identified an area of concern. This area was problem-solving and the children's lack of understanding of any problem-solving strategies outside of mathematics. It became apparent to me that the children had not been exposed to problem-solving skills outside of mathematics and therefore had low confidence when posed with problems. Having a background in CT, I had first-hand knowledge of its potential benefits and growing significance in education. As a result of my concerns and this interest in CT, I constructed my research question: *How can I enhance my teaching through the use of CT as a problem-solving strategy?*

1.2 Research Background, Context and Intervention

My experience in primary school was what drove my interest in becoming a teacher. We were not given any agency in the school and completed all of our work in books. My mother is a teacher, and I knew all schools were not the same. This is where my value of child-centred learning and guided discovery developed. I saw how my mother taught and knew I wanted to be like her. Every day, I wanted the children in my class to leave smiling but also having gained useful knowledge. I believed children could construct their own learning through discovery and play.

My values of perseverance and adaptability came to focus during the first Covid-19 lockdown. As I was not working in a school at the time, I watched as essential workers adapted to the situation and continued to persevere and go to work every day. I knew I wanted to demonstrate this to my class, to enable them to have that same strength and ability.

As mentioned, I have a background in CT, working and studying in the area. I have always had an interest in digital technology but this interest in CT formed when one of my secondary school teachers, now friend, introduced me to coding. I immediately became fascinated and began researching the area myself. I regularly use CT when faced with various problems. It enables me to face challenges with confidence that I can find a solution. I completed my Bachelor's degree in Education, majoring in digital technologies, knowing that I wanted to use CT in my classroom and allow my students to benefit from it, as I had.

The context for the research is a co-educational, rural Dublin school where I teach 1st/2nd class. It is a multigrade setting and the children in 2nd class have had me as

their teacher for a year. The children are not readily exposed to digital technologies and there is a focus on community and friendship in the school.

The intervention for my research was influenced by my values and experience of CT. It focused on the integration of CT through guided discovery and activities not involving technology. The aim was for the children to understand that these skills were transferable and do not rely on digital technologies. The intervention involved explicit teaching of the concepts of CT along with guided discovery sessions where the children formed their own understanding and learning.

1.3 Potential Contribution of the Study

The potential contributions of explicitly teaching CT enables children to develop an understanding of problem-solving strategies and the confidence to persevere (Wing, 2006). By modelling and teaching problem-solving strategies outside of the mathematics curriculum, children develop an understanding of how to approach challenges outside of school (Kapur, 2020). Using guided discovery as a method of teaching CT allows children to form their own understanding of the skills and how it can be a beneficial life skill (Greene, 1995).

1.4 Outline of Chapters

1.4.1 Chapter One

Chapter one provides a background of my research focus and concerns. It includes an introduction to the concerns I have pertaining to my practice, the children in my

classroom's learning experience and the teaching of problem-solving in education. I identified my personal and professional values through reflection. This chapter includes a brief synopsis of them and their effect on my practice. A short summary of the research intervention is included.

1.4.2 Chapter Two

Chapter two presents a critical review of literature relating to my action research study and the theory that supports it. It focuses on establishing an insight into the current educational standpoint and guidance on the importance and teaching of problem-solving, CT and the use of digital technologies. The chapter provides a definition of CT and provides an argument for its benefits as a life skill. I also discuss the current policy and curricula in Ireland that refer to problem-solving and digital technologies and their use in the classroom.

1.4.3 Chapter Three

Chapter three focuses on the research design and rationale for the action plan. I provide a detailed description of the full classroom intervention and relevant cycles. I discuss the research environment and provide a background to the chosen topic. The chapter justifies the decision to select action research as the research paradigm and outlines the important elements underpinning it. I explain my reasoning for the chosen data collection tools and storage. The chapter includes an acknowledgement of the ethical guidelines considered while undertaking the research.

1.4.4 Chapter Four

Chapter four illustrates the data analysis and explores the benefits of using CT as a problem-solving methodology in my classroom. The chapter discusses the relevant

findings relating to the teaching methodologies and CT skills I integrated, and the effect it had on myself as a professional and the children as learners.

1.4.5 Chapter Five

Chapter five includes a summary of the main findings discussed in chapter four and provides a context for the results. I identify the significance of my research to my own practice and the wider educational field. I provide a statement of my claim to knowledge pertaining to CT as a problem-solving strategy and life skill. I identify the limits to my study and note recommendations for future studies in the area of CT and problem-solving.

2. Literature Review

2.1 Introduction

The purpose of a literature review is to draw people into a practice of reflecting on and inquiring into aspects of literature (Freer, 2008). Therefore, this section of the paper will pose a critical review of already published literature associated with the proposed question and relevant topics, specifically Computational Thinking (CT) as a problem-solving strategy. This chapter will discuss the definition of CT that will be used for the purpose of this research.

This chapter is divided into a number of different distinct sections. The first section begins by discussing literature on problem-solving in the primary school classroom. As digital technologies will be used as part of this study, the next section will be focused on digital technologies and the importance of their use in the classroom. The next sections will then discuss CT in terms of its definition of use. As block-coding is going to play a significant part in this study, it will also be discussed alongside the method of research that is going to be used.

2.2 Problem-Solving

The importance of problem-solving in our lives has been recognised in volumes of different research (Voskoglou, 2016). It has been agreed throughout these volumes of research that problem-solving is not limited to only Mathematics, but to our everyday lives (Kapur, 2020). Improving children's ability to solve problems is critically important for effective learning and is recognised as a crucial skill in education (Yurtseven et al., 2021). The development of problem-solving begins at a young age,

when infants decide to walk when wanting to move further distances (Keen, 2011). It continues for our entire lives, and yet nowadays there are still graduates who have difficulty when solving real life problems (Voskoglou, 2016). In this section, I will be critically analysing and discussing relevant literature on problem-solving.

Problems are an intrinsic part of our daily lives (Kapur, 2020). Problems occur in all aspect of our lives: in the workplace, at home, in social situations etc. In some cases, the problems require more effort to solve than in others (Yurtseven et al., 2021). Sometimes, different approaches are used to solve the problem, other times problems are unconsciously solved. Both Yurtseven et al. (2021) and Kapur (2020) discuss approaches taken to problem-solving. Kapur (2020) writes that it is important that we hone our problem-solving skills as they are necessary for life.

Yurtseven et al. (2021) explain how decision-making is an important aspect of problem-solving, where one does not occur without the other. They delve into numerous definitions of the term problem-solving and settle on the understanding that problem-solving is an activity, task or situation where the end solution is not initially identified (Voskoglou, 2016). Problem-solving involves obtaining information and using skills to find solutions to different problems. It is a continuous and conscious process which aims to reduce undesirable conditions (Tallman, 1988).

As mentioned, Yurtseven et al. (2021) discuss how problem-solving does not happen without strong decision-making skills. Children need to make a number of different decisions before cultivating a solution, and it is important that this process is not rushed. The decision-making process is crucial and is often the factor that determines the success of a solution (Hershey et al., 1990). There are a number of steps

that we follow when making a decision, as discussed by both Kapur (2020) and Yurtseven et al. (2021). An important step that is discussed in this process is framing. Framing can be described as looking at a problem in different perspectives and considering the different elements of the problem to be solved. Good decision makers design decision frames for different problems (Yurtseven et al., 2021). By using this framing technique when making decisions, one can determine which solution best suits the problem at hand (Holtzclaw, 2012). Kapur (2020) discusses how one must use all of one's knowledge to cultivate a solution to a problem. They make reference to using technology and communication to brainstorm modes of finding a solution. Kapur (2020) believes that one must answer specific questions while problem-solving to come to an overall solution. These questions involve finding alternatives and causes of the problem so one can see it more broadly. They argue that one must fully understand the problem before they can solve it. Conversely, Yurtseven et al., (2021) discuss how one can solve problems without even consciously realising it.

Yurtseven et al., (2021) discuss a 10-step model approach that Yahaya and Yusuf (2018) believe everyone takes when tackling different problems. The text delves into detail about this approach and summarises that this crucial decision-making occurs in the ninth stage, before the final implementation stage. However, Kapur (2020) would argue that decision-making is not only limited to this final stage but is continuous. He discusses the importance of decision-making in problem-solving and says that when a problem is significant enough, one should seek advice from others around them. He states the importance of collaboration and how it makes problem-solving tasks more manageable. Individuals perform better when working in groups than when working

independently (Kapur, 2020). Different ideas can then be spoken about, and decisions are easier to make when finding an effective solution.

Güçray (2001) examined the effect that self-esteem has on problem-solving, which Yurtseven et al., (2021) also explored. They discussed how one's problem-solving skills can be affected by situation, location or emotions, just like self-esteem. An interesting point that both Yurtseven et al. (2021) and Güçray (2001) also discussed was the effect that gender had in their research and findings. The pieces of research have conflicting outcomes, one finding that females reported themselves as being more confident when finding solutions than males, and therefore performing stronger, but yet the other research found that males performed better. Both papers spoke about the importance self-esteem and confidence has on problem-solving, which links to Kapur's (2020) point that collaboration, where support is given, improves the reproducibility of problem-solving.

Cornoldi et al. (2015) discuss how they used working memory and metacognition to aid in the enhancement of students' problem-solving skills in mathematics. The children were aged 8-10 and were based in northern Italy. The children periodically worked on different activities and challenges to improve these skills. At the end of the research, the children had developed a deeper understanding of and ability to problem-solve.

Nunes, et al. (2015) also discuss the teaching of problem-solving skills and mentions how there is a plethora of different methodologies to do so, but no universally accepted framework for choosing the appropriate one. Their research focused on different mathematical questions and how children, of a similar age to those in Cornoldi

et al.'s (2015) data, could approach problems differently. Similarly to Cornoldi et al. (2015), the children completed a range of challenges that progressively increased in difficulty. However, the skills developed were not limited to mathematics. Nunes, et al. (2015) also refer to the development of skills related to understanding assumptions and representing findings in different ways to help the process.

In conclusion, decision-making plays a crucial role in the problem-solving process and working in collaboration with others can aid in the process (Yurtseven et al., 2021; Güçray, 2001). There are a number of different problem-solving models and approaches, some that are subconsciously done and others that require planning and questioning (Kapur, 2020). An extensive range of problem-solving teaching strategies exists, but there is considerably less guidance on what ones are of most benefit (Nunes, et al., 2015).

2.3 Digital Technologies in the Primary Classroom

The term Digital Technologies is used to define digital resources that help the user, ranging from computing hardware, personal computing devices to game consoles (Selwyn et al., 2010). Digital technologies play a key role in our lives. They occupy a very relevant position, being our means of: communication, entertainment, study, work, transportation, etc. With that said, education has taken a drastic turn or second revolution in the past number of years (Collins & Halverson, 2009). Now, Information and Communication Technology (ICT) plays an essential role in the teaching of both primary and secondary school's curricula. Both Collins & Halverson (2009) and Selwyn et al. (2010) agree that these technologies play a significant role in the child's

development. Berry (2013) linked the use of digital technology to 19th century German educationalist Fredrich Froebel's idea of play. His paper argues the fact that digital technology is now as important as play is for children's development. This is an interesting point as many could be see play and 'computational process' as diametrically opposed.

Integrating digital technology into the classroom and the school's curriculum helps increase engagement and motivation in lessons (Pinto-Llorente et al., 2018). With play, children are given the opportunity to learn through the process of design, creation, experimentation and exploration (Berry, 2013). The use of digital technology is almost parallel to that. Digital technologies are a huge aspect of the child's life in the 21st century and therefore, by using these, we are meeting the needs of their technology-saturated lifestyle (Selwyn et al., 2010). However, it could be argued that digital technologies may only benefit those who will enter into a technologically focused profession and not those whose profession will involve computational devices, which is limited in the 21st century. Berry (2013) argues that we do not teach art in the classroom in the hope that our class will become artists. We do not use building blocks during play to ensure our class become architects. Berry (2013) questions; Why should we teach technology to prepare our class only for the world of work? Digital technologies have a greater effect than that on all children (Collins & Halverson, 2009). They amplify both child and teacher satisfaction in understanding the topic being taught (Pinto-Llorente et al., 2018). In today's world, technology is as familiar to children as using kitchen utensils to eat (Buzzard et al, 2011). We need to work with this familiarity and allow our students to use the 'tools' at their disposal to develop skills and competencies that they will need in their future lives. Gürbüz, et al. (2016) even discusses how computer

games can be used to teach problem-solving strategies in the classroom. Berry (2013) asks the question does finger painting on an iPad differ that much than on sugar paper? As educators, we have a chance to use this tool to help further our students' development (Selwyn et al., 2010). By using what they already know and understand, we help them develop their skills without them even realising.

The use of digital technology expands the content available to children and moves away from the 'teacher knows all' approach (Collins & Halverson, 2009). This use of a constructivist approach assists with the children's critical thinking as they are able to research a topic themselves and work out the answer instead of relying solely on the teacher's knowledge. It goes beyond the basic hands-on approach to learning, as it gives children control over the problems that they are solving (Resnick, 1990). The child can broaden their understanding of topics independently, using technology. This then introduces the opportunity of child-driven or peer-to-peer learning. Child-led learning, personalisation and collaboration can all be enhanced with the integration of digital technologies (OECD, 2017). Children also learn through experimentation and 'fixing' things that do not work for them (Berry, 2013). While researching online, they may have to edit their search to find specific answers or research. In the world of coding, debugging is extremely important, and this is where the development of critical thinking skills take place (Messer et al., 2018).

Digital technologies can be extremely beneficial in the classroom but can also be difficult to manage (Collins & Halverson, 2009). Selwyn et al. (2010) discuss the pressure on schools to use digital technologies on a day-to-day basis. This can lead to a teacher-led approach to technologies, which is not as beneficial to children (Selwyn et

al., 2010). The subject approach is an approach where ICT is interwoven throughout all subjects and is the approach that is recommended in the Digital Learning Framework (DLF) (DES, 2017). Collins & Halverson (2009) emphasise the importance of this, highlighting that if ICT is not integrated correctly, education will suffer. Students will be at a loss once they leave education and enter a technology driven workforce. The DLF aims to become a reference for schools to enhance the teacher's digital competency and avoid this loss for our students. This framework (DES, 2017) has many benefits to schools, including the subject approach of integrating digital technologies into the different curricula, as mentioned above. One of the overall expected long-term outcomes of the framework (DES, 2017) is to help students and teachers use computational devices effectively for learning (DES, 2017).

2.4 Unplugged vs Plugged Activities

The terms 'unplugged' and 'plugged' activities are widely used when explaining CT. Bell et al. (2012) explains the term 'unplugged' as activities that promote the development of CT skills without having to engage with digital devices. In contrast, a 'plugged' activity involves the use of digital devices. Ahamed et al. (2010) discuss how unplugged activities foster an interest in students towards CT and how teachers play an intrinsic role in delivering them correctly. In their research, they compared the use of unplugged and plugged activities to promote an interest in computer science. In contrast, Bell et al. (2012) explored the benefits of using unplugged activities to teachers. Collectively, both found the unplugged activities initially more beneficial than ones using digital devices.

Hermans & Aivaloglou (2017) talk about how teachers play a key role in the delivery of these activities and the movement from them to plugged activities. They explore the benefits of focusing on unplugged before moving to plugged. By using this order of activities, the children have a background on the skills needed before engaging with technology (Hermans & Aivaloglou, 2017). A study was conducted where students engaged in unplugged and plugged activities in different orders. Post lessons, in the group where the students engaged in unplugged initially, they were seen to be more confident in their abilities and have a better understanding of the skills. This links to Bruner's (1976) discussion on how the order of activities presented to a child can benefit or hinder their understanding.

2.5 Computational Thinking

CT is primarily accredited to Jeannette Wing (2006) and can be defined as the thought process involved in detailing problems and cultivating solutions in a way that allows a computational device to carry out the solution (Pinto-Llorente et al., 2018). This term originated with Seymour Papert (1996), yet Wing's definition is more modern and focused on problem-solving (Dagiene & Sentance, 2016). Brennan & Resnick (2012) discuss how CT is primarily a thought process, which involves formulating problems and solutions in a way that a computational device can carry out the solution. However, Csizmadia et al. (2015) state that CT is the development of a thinking skill, rather than a process, and supports learning and understanding. Despite the confusion over a concrete definition of the phrase, it is clear that CT is a fundamental skill for everyone and not only those working in the realm of technology (Pinto-Llorente et al., 2018).

CT is not a term that is entirely embraced by all, as some argue that the term is narrowing (Dagiene & Sentance, 2016). However, Wing (2006) pitches CT as a set of skills that all people need to develop to survive in the 21st century. She also discusses how CT is an integral part of childhood education and highlights its importance in a child's life. Zaharin et al. (2018) agree with Wing and discuss how CT can provide children with the tools to generate solutions to problems. They agree that CT is a set of skills that should be applied to everyone, not solely to those who are interested in computer science.

CT can be broken down into different concepts: Decomposition, Generalisation, Patterns, Abstraction, Algorithms and Evaluation (Berry, 2015). Berry (2015) defines these concepts as follows: *Decomposition* is the process of taking a problem and breaking it down into smaller, more accessible parts. *Generalisation* can be defined as a concept of grouping together classes of problems. The meaning of the term *Patterns* in this context is recognising and categorising them appropriately, thus solving them. *Abstraction* is the simplifying of complex ideas within problems to assist in making them more approachable. *Algorithms* are the sequence of instructions that are given or a set of rules that are made for the completion of a task (Berry, 2015). Csizmadia et al. (2015) disagree with Berry (2015) and discuss how *Evaluation* should be considered a concept. This is where the user is assessing the solution and ensuring that it is fit for purpose. If there is a problem or 'bug' in the solution, the user can debug and therefore solve it.

Messer et al. (2018) discuss how there are only four pillars to CT. They use Sudoku to explain each of the four pillars that they believe are most important. They

use the same definition of *Decomposition* as Berry (2015). Sudoku puzzles are already broken down into smaller parts and to solve them, the player must take each line or box at a time. *Pattern-matching* is described as finding similarities between items and using this as a means of gaining beneficial information. Messer et al. (2018) use the process of comparing the different lines in the puzzle and working out which numbers are missing to describe this pillar. The definition of *Abstraction* that Messer et al. (2018) use is ignoring over-specific details to help cultivate a solution that suits the overarching problem. In the puzzle, *Abstraction* is the act of looking at the overall instructions given when solving and abstracting them out to find the final algorithm. *Algorithms*, also referred to as automations in this piece, are defined as a list of simple steps that, when followed, complete the task. The instructions given to solve the sudoku represents the algorithm.

Even by the use of the sudoku metaphor to describe CT, we can see that it is necessary to teach children the digital language and key digital skills needed to be a part of the current world (Pinto-Llorente et al., 2018). These skills are being subconsciously developed through unplugged activities, when instead we should be harnessing them and promoting the development of these necessary skills in the classroom. Through the use of classroom computational devices, children will become more confident using digital language and will be more prepared to enter into a digitally focused world (Collins & Halverson, 2009).

2.6 Promoting Computational Thinking in the Classroom

CT can be perceived as a unique means of problem-solving, whereby we draw upon computer science concepts to solve everyday problems (Shute et al., 2017). Kale & Yuan (2021) explain how important it is for educators to teach our students how to problem-solve. Educators must help them develop the knowledge that they will need to solve everyday problems. Kale & Yuan (2021) explain how rapidly our world is changing and how our students now require different skills for jobs, education and technology-rich lifestyles. This introduces the importance of using CT to solve problems. But how can we develop this vital skill in our classrooms?

Dagiene & Sentance (2016) discuss how CT can be introduced into the classroom through a number of different problem-solving tasks which they call Bebras. Bebras is a challenge that has been running for over 12 years where schools partake in these tasks to help introduce CT to their classrooms. The schools are invited to solve a number of short, concept-based tasks to promote digital competency (Dagiene & Sentance, 2016). The schools participate in online challenges to promote CT. Kapur (2020), discusses the benefits of using technology to cultivate solutions to problems. Dagiene & Sentance's (2016) paper discusses how schools do not need to partake in the challenge to integrate these challenges into their school and suggests a number of different sample activities. It is important to note that the definition of CT that Bebras focuses on is one that reiterates CT as a problem-solving strategy in everyday activities. Bebras explores the different pillars of CT, as discussed above, and breaks down the different activities according to each pillar. Bebras uses Csizmadia et al.'s (2015) aspects of CT: abstraction, algorithmic thinking, decomposition, evaluation and

generalisation. Dagiene & Sentance (2016) acknowledged that some tasks develop more than one pillar but there is always one at the forefront They discuss the difficulty in generating tasks that demonstrate decomposition or evaluation, but these pillars are still met in other challenges.

Dagiene & Sentance (2016) present a number of examples for each of the pillars of CT. For the purpose of this literature review, one example will be discussed. A challenge called 'crane operating' is an example given to aid in the development of *algorithmic thinking* (Dagiene & Sentance, 2016). In this task, the children are shown images of a crane and directional symbols: up, down, left, right, open claw and close claw. The challenge is to move box A to where box B is sitting and vice versa, by creating a sequence of instructions using the symbol buttons provided. The challenge is timed and both boxes must be moved before the other can sit in its place. This task challenges the children to break the movement of the crane down into each individual step (decomposition) and place them into the correct sequence to complete the task (algorithmic thinking). This links directly to the definition of algorithms posed by Messer et al. (2018); a list of simple steps, that when followed, complete the task. This task links directly to an unplugged activity explained by Threekunprapa & Yasri (2020). They give their students access to a map and the children are to plan a route, avoiding the 'bombs', to reach the treasure.

The above is an example of developing CT as a problem-solving skill digitally, however CT can also be developed by unplugged activities. Zaharin et al. (2018) discuss how CT can be used as a strategy for developing and promoting problem-solving skills and also discuss the use of unplugged activities. Though their research

focuses on a Malaysian student context, it is still relevant in the research carried out here. Similarly, Threekunprapa & Yasri's (2020) study is focused on secondary students, but the study is still relevant to this research, in that they discuss how CT can be integrated and promoted through plugged and unplugged activities. The definition of unplugged activities being used is the use of tasks that do not include the use of tools or digital technologies (Zaharin et al., 2018). Threekunprapa & Yasri (2020) mention how introducing CT into the classroom can be expensive and using unplugged activities is a more cost-effective plan for educators. Zaharin et al. (2018) discuss how CT can be introduced into the classroom through the means of games, such as *Simon Says*, or as passively as breaking down words to gain understanding. Similarly, Threekunprapa & Yasri (2020) use an unplugged coding game encompassing five challenges for their students to introduce CT, as explained above. They argue that their unplugged method can be more beneficial to students as they do not become reliant on computers but learn to think like them. The unplugged activities act as a scaffold to their learning and understanding before moving onto computational devices. This leads to a better understanding of algorithms with less debugging and error, particularly when working with primary school children (Threekunprapa & Yasri, 2020).

Zaharin et al. (2018) use the example of the word photosynthesis and how when decomposed into 'photo' meaning light and 'synthesis' meaning produce, students gain a deeper meaning of the word. Though this example is not suited to the target age of the research, the same method could be used. Zaharin et al. (2018) also discuss how introducing magic tricks to a class can promote CT as a problem-solving strategy. This consists of the child who is executing the magic trick who must sequence their movements precisely to perform their magic trick, and also the 'audience' who must

watch and decompose the actions to work out the 'how' (Zaharin et al., 2018). Other than the two above tasks, Zaharin et al. (2018) also suggest the use of board games, as here the children are actively problem-solving. They are carefully sequencing their moves, evaluating each move and abstracting information from their competitors.

*'Tinkering' (*Zaharin et al. 2018: 1271) is another term that is used in this research. It can be defined as a means of trial and error. This is similar, if not identical, to Messer et al.'s (2018) use of the term debugging, whereby one implements a plan of action and continues to edit the plan until perfect. Allowing *tinkering* in your classroom gives children more freedom when investigating new ideas, and they are working in a creative environment that allows them to explore deeper (Zaharin et al., 2018). It is with this independence and informal exploration that CT can be developed and therefore used for problem-solving (Messer et al., 2018). Persevering is one of the final terms used by Zaharin et al. (2018) to develop CT and is described, by them, as being the best. They discuss how plugged activities promote the development of perseverance as they drive children to explore new ways of approaching the task. This links directly back to *tinkering* as they must continue *tinkering* until they have a solid solution that is suitable for the problem with which they are challenged. Zaharin et al. (2018) discuss how it is important to instil confidence in our students and promote collaboration at this stage, as it is an important stage to persevere through. They use brainstorming as an example of how to support this as an educator, since it aids the problem-solving and thinking process (Zaharin et al., 2018).

Resnick (2015) also talks about the importance of educators giving their students the ability to tackle problems creatively. Educators should be preparing them

to creatively adapt to situations and use resources available to solve problems. Pollak & Ebner (2019) agree, saying that by introducing children to CT, we are preparing them to deal with more complex and open-ended problems. By introducing this, we are preparing a generation that are more adept and prepared to cultivate solutions to challenges they are posed with (Pollak & Ebner, 2019).

> *'By allowing youth to solve problems in ways experts and engineers around the world do, they learn to utilize the most powerful tool—their brain. '*
>
> (Pollak & Ebner, 2019:11)

In 2019 the NCCA published a report discussing the benefits of coding in primary schools. This report mentions CT and its integration into the curriculum through the use of digital technologies. In 2017 an initiative began with schools introducing coding into the classroom. Teachers were given guidance on how to introduce digital technologies into their teaching and interviewed at the end of the process. This study included schools from various settings around Ireland and found that CT deserved a place in the Irish primary curriculum as it proved beneficial to teachers, parents and children. It also concluded that the use of CT improves children's problem-solving skills and prepares them for the 21st century (NCCA, 2019).

2.7 Enquiry Based Learning and Guided Discovery

John Dewey and Maxine Greene, modern 20th century educational philosophers, highlight the value of active and enquiry-based learning in the classroom as a means of preparing their students for the future.

Westbrook discusses how Dewey devoted his life to his idea of democracy (Westbrook, 2010). He saw the children as little adults who needed to learn about the world that they were going to live in. The children were empty vessels, who had not yet been tainted by the outside world. It is our job as teachers to filter out what is being taught in the classroom to genuinely assist in the children's learning (Westbrook, 2010). Westbrook (2010) states that, in the past, teaching was delivered with a very narrow outlook on the world, where children were prepared to enter into specific occupations. Dewey aimed to make a change and provide children with all of the information needed to enable them to make their own decisions and live life in a democratic way in the future (Noddings, 2010).

Greene (1995) also poses the idea that there needs to be a broader outlook on education where there is not just one primary goal. Teachers need to provide opportunities in our classrooms for children to question their thinking and decision-making abilities. Bruner (1976) has similar opinions on education, stating that learning should serve the children's future. Education should challenge their outlook and henceforth challenge their future (Greene, 1995).

Jerome Bruner coined the phrase 'discovery learning' in 1960's and similarly to Dewey and Greene he emphasised that children should learn by doing. Discovery learning is an inquiry-based constructivist approach to education, where students develop skills or understandings through independent or group exploration (Bruner, 1976). The difference is that Bruner (1976) focuses on the children's ability to develop understanding through self-directed learning, similar to Froebel's opinion on play (Brosterman, 2003). Bruner (1976) discusses how correctly designed discovery sessions

enable the learner to develop an innate ability to recognise problems. Froebel echoes this, stating that young children develop a deeper understanding of life through exploration and play (Tovey, 2016).

Bruner and Froebel discuss the importance of having structure to guide the learner in the right direction (Bruner, 1976) (Tovey, 2016). They refer to the correct ingredients needed for these sessions to be beneficial for children. The students develop the generalisation that lies behind different problems and therefore develop a deeper understanding (Bruner, 1976). They explore aspects of the activity they may not have explored before and gain powerful first-hand experience with problem-solving (Tovey, 2016).

2.8 Child-Centred Approach

Greene and Dewey believe that the emphasis in the classroom should be on the child and the child's individual learning (Greene, 1995). In contrast, Dewey focuses more on how the teacher needs to filter out what the children need to learn and what they want to learn (Dewey, 1916). He believes that while it is important to focus on what the children want to learn, it is also vital that the curriculum gets covered. Greene (1973) talks about how standardised testing and results are taking priority in the classroom. She believes that the teacher needs to be able to balance the curriculum alongside the children's interests and needs (Greene, 1973).

Dewey is not perceived to be a child-centred philosopher in education (Noddings, 2010). His focus is primarily on the future and how the children will grow up to be beneficial to society (Ryan, 1998). In contrast, he does believe in the

importance of the individual's thoughts, beliefs and ideas in the classroom. Dewey and Rousseau both agree that aims for children may have to be differentiated (Noddings, 2010). Rousseau (1762) talks about the benefits of incorporating children's interests into lessons. Dewey disregards this and discusses how teachers are there as a filtration system. Educators are to filter these interests and work them into the curriculum in a way that will benefit them in the future. Greene (1995) has similar beliefs to Dewey in this regard. She believes that the teacher's emphasis should always be on the needs and interests in their classroom, not only on the subject matter.

2.9 ICT and Coding

There is a wide range of digital, educational tools available to promote the development of CT and the majority of them include robotics and visual programming, for example, Scratch and Micro:bit (Pinto-Llorente et al., 2018).

2.9.1 Block Coding

Coding is a language that is used to give computers a set of instructions to execute (Miller, 2019). There are a variety of coding languages, for example JavaScript, that traditionally comprise of numbers and letters called syntax. Frequently educational resources remove syntax when coding and provide a colourful and child-friendly environment for children to code, using blocks. They use drag and drop features and promote a good programming practice (Kazimoglu et al., 2012). Berry (2013) discusses the link between building blocks in coding and in play. Children can learn through playing and experimenting with the blocks and develop an understanding of how the program works. Once they have developed an understanding through play, they can slot

the pieces together and develop their own original program (Berry, 2013). He mentions how block coding can be taught as a teacher led lesson with little to no scaffolding. In these lacklustre lessons, the children are being denied the ability to explore and understand the blocks independently. The code is provided for them, and they take on a copy and paste approach (Berry, 2013).

Block coding promotes CT as it encourages the user to break problems down and cultivate a solution (Ball et al., 2016). However, Kazimoglu et al. (2012) poses a different view, and argue that this simplified form of coding may promote a linear approach to coding. In this approach reusability and other coding practices, such as the use of loops as opposed to repeating the same code multiple times, are not considered. Berry (2013) argues that children will develop this understanding in time, while experimenting with the platform. Ball et al., (2016) explain how the interface is designed to provide students with an understandable programming environment. They discuss how this coding language promotes the use of loops and more complex coding concepts, as they are more approachable and easier to understand than in syntax (Ball et al., 2016).

2.9.2 Micro:bit

Micro:bit is a microprocessor with a 5x5 LED display, a number of sensors, programmable buttons and five input and output rings (Appendix A). A number of different programs can be used to programme Micro:bit, however, MakeCode by Microsoft is the most popular (Ball et al., 2016). MakeCode allows the user to use block or syntax coding. When used in the classroom, children can take on the approach mentioned by Berry (2013). They can explore the blocks and develop CT

independently. On the coding platform, there is a simulator that promotes students constantly testing their code and debugging as they go (Ball et al., 2016). They are decomposing problems, creating algorithms, recognising patterns and evaluating their code.

2.9.3 Lego Education

Pinto-Llorente et al. (2018) use the computational resource Lego WeDo to help further examine the benefits of technologies in the classroom. The Lego Education WeDo kit is an easily accessible construction kit with approximately 150 elements that enables the user to build and code different creations using the compatible software. It was designed and created by the Lego Group in collaboration with the Massachusetts Institute of Technology (Pinto-Llorente et al., 2018).

Lego Education provides the user with a '4C framework': connect, construct, contemplate and continue (Pinto-Llorente et al., 2018). This framework is aimed at helping the children reach their full potential and effectively complete a build that will solve a presented problem. It allows children to explore and experiment with the resource before working with it (Pinto-Llorente et al., 2018).

2.9.4 Scratch

Scratch was designed by Mitchel Resnick at the Massachusetts Institute of Technology Media Lab (Liao, 2022). It is a free, child friendly visual programming language designed to act as an introductory programme to coding (Liao, 2022). The Scratch programme is designed to allow users build projects using media such as, images and sounds. It was originally designed for children (8 to 16 year olds) with its child friendly interface and colourful layout (Maloney et al., 2010). The children can programme

different 2D objects, called Sprites, to move and interact with a background, called the stage. Scratch builds on the constructionist idea of allowing the user to personalise their coding projects by importing their own media and therefore making their project more personally engaging (Maloney et al., 2010). Liao (2022) discusses how they used this programme to design and create fun and interactive projects with their students. Similarly to Micro:bit, the coding platform encourages the user to develop a deeper understanding of coding by testing the code and debugging (Liao, 2022).

2.10 The development of ICT and Problem-Solving in Irish Policy

ICT and problem-solving have been mentioned in academia and policy for years but have only become more frequently discussed in Ireland in recent times.

2.10.1 Digital Learning Framework

The Digital Learning Framework (Department of Education, 2017) aims to become a reference for schools to observe teacher's digital competency. This framework (Department of Education, 2017) has a range of benefits to schools including the subject approach, integrating digital technologies into the different curricula. As referenced by Selwyn et al. (2010), this approach has sparked strong debates within schools about its added pressure to teachers when planning. This framework (Department of Education, 2017) gives the teachers a reference as to what is considered best and most effective practice within the classroom.

2.10.2 Information and Communications Technology (ICT) Framework

The ICT framework (NCCA, 2007) was designed as a structured approach for teachers using ICT in curriculum and assessment. It aims to identify the appropriate learning for students while in education (NCCA, 2007). It is constructed to act as a guide for teachers when embedding ICT into their teaching and planning. Unlike the Digital Learning framework, the ICT framework provides teachers with individual learning outcomes for students to achieve (NCCA, 2007). It enables students to develop a deeper understanding of ICT and how it can be used effectively.

The ICT framework aims to enable teachers to support their students develop a wide range of skills relating to ICT, including problem-solving skills (NCCA, 2007). It encourages the use of ICT as a means of developing problem-solving skills and promotes the integrated use of ICT in the classroom.

One of the overall expected long-term outcomes of the DL framework (Department of Education, 2017) and the ICT Framework (NCCA, 2007) is to help students and teachers use computational devices effectively for assessment learning. These devices encourage the children's development of CT skills, as seen in the research collected by Pinto-Llorente et al. (2018).

2.10.3 Draft Primary Curriculum Framework (DPCF)

The DPCF (NCCA, 2020) was designed as a means of reviewing and redeveloping the current Primary School Curriculum (1999). It discusses the rationale for the draft framework, a detailed description of the process undertaken and a timeline for the developments. The vision is to provide every child with a strong foundation to flourish

and to support them to develop to their full potential as they enter into society (NCCA, 2020).

The draft framework discusses the key competencies that play a significant role in children's learning. They are embedded throughout all curriculum areas and all class levels (NCCA, 2020). One of the competencies mentioned is *'Being a digital learner'* (NCCA, 2020: 9). This aspect of the framework discusses the importance of a child's ability to critically engage with and contribute to a digital, interdependent world. The attributes associated with this key competency mentions the ability to problem-solve using digital technology, amongst others. The DPCF continues to delve deeper into the detailed implementation of the framework, continuously viewing the child as the central stakeholder in their learning (NCCA, 2020).

2.11 Action Research

Action Research is defined as the practical way of looking at one's own work and comparing it to one's ideals (McNiff, 2002). It is carried out by the practitioner on the practitioner and can also be referred to as self-reflective practice. The process is open ended and works with a constantly developing idea (Brydon-Miller et al., 2003). This involves the researcher continuously ensuring they are in line with their values and what they intend to happen (McNiff, 2002).

Brydon-Miller et al. (2003) discuss the criticism action research has received in previous years, where researchers found the term puzzling since there was no scientific input. McNiff (2002) discusses the benefits of action research and how we all carry it

out informally in our lives. McNiff (2002) uses terms such as investigate, evidence and data which could be classified as scientific language.

Brookfield, in McDonagh et al., (2020), illustrates the benefits of action research to education. He explains his own journey and the realisations he made about himself as a practitioner and his practice. McDonagh et al. (2020) provide a detailed guide on how educators can engage in classroom-based action research to enhance their practice. They explain how, in Action Research, educators critically reflect and analyse their own practice. Educators develop an understanding of how their students experience teaching and learning in their classroom. Action research involves teachers critically reflecting on their own practice and identifying areas of concern or an area they would like to enhance. They then develop a plan and implement it in their classroom. The process requires the researcher to identify their values as a professional and identify the impact on his/her practice, if any (McDonagh et al., 2020). Action research requires the students in the classroom of the researcher to not only take part in the research but to become co-researchers (McDonagh et al., 2020).

2.12 Conclusion

To conclude, the literature discussed in this chapter explored the hypothesis that CT can be used as a problem-solving strategy to enhance teaching through the use of unplugged and plugged activities. It also discussed the relevant policies in Ireland and offered an introduction into Action Research. In the next chapter, I will outline the methods and procedure employed in this study.

3. Methodology – Action Plan

3.1 Introduction

This chapter will discuss the methodology used and actions taken throughout this research process. It will first discuss the research paradigms used and justify choosing action research as the paradigm. A narrative of the research will then be given followed by a description of the cycles planned and taken. The chapter will then discuss the means of data collection and the ethical considerations that have been made. The chapter concludes with an explanation of the validity and reliability of the research.

The catalyst for this research is my ontological and epistemological values of perseverance, adaptability, guided discovery and child-led learning. It is my opinion and belief that we are not prepared in the education system to deal with the fluidity of solving life problems. It is also my understanding and experience that we are given a very basic structured approach on how to solve structured and measured problems. I believe that the implementation of computational thinking (CT) as a problem-solving strategy can be hugely beneficial to children. I further believe that this can be introduced into the classroom. I, therefore, chose to reflect on and analyse my own teaching practice to interpret if I was allowing the children in my class to develop a more fluid understanding of problem-solving. As the intention was to evaluate my own practice, the paradigm chosen for this research is self-study action research.

3.2 Research Paradigms

A paradigm is a means of viewing or researching phenomena (Cohen et al, 2011). It is an intellectual framework that allows research to exist (Kuhn, 1970). The paradigm chosen for this research was constructivist action research. Critical theory was used as a means of operating within the paradigm, with the aim of improving or critiquing my practice. It involves having the researcher's core values at the centre of the research. It is a collaborative process where the researcher is at the centre. The researcher then makes sense of their findings and poses a claim to new knowledge or a new theory of practice. Critical theorists would argue that interpretive paradigms seek to gain an understanding rather than make a change, question and transform it. The intention of critical theory is not to give a detailed account of practice or to understand phenomena but to make a difference and change them. Its purpose is to be transformative. This links into the purpose of this research, as my aim was to make a change and enhance my teaching.

Action research is a term used to define a specific means of evaluating one's own practice to insure it is how you believe it should be (McNiff, 2013). As it involves one carefully reflecting on one's own practice it becomes a critical self-reflective practice (McNiff, 2013). It is a collaborative process where interactions with others play a central role in the process. The plethora of action research methods in self-study can be quite broad and varied. However, the majority is qualitative in nature. The children in my classroom were an integral part of my research and therefore a collaborative means of researching was chosen. They experience the learning in the classroom and their thoughts and opinions are crucial for me to understand my

teaching. My value of child-centred learning is also highlighted here. I want the children to be stakeholders in the learning that takes place and therefore action research was my ideal choice.

Action research is a cyclical process which pertains to practitioners engaging in many cycles. The process involves continuous reflection and evaluation which leads us away from the traditional linear structure of research (McNiff, 2002). The adaptability of the entire process links into my core values. The problem-solving nature also has direct ties to my values and the purpose of this research. Not only am I as the researcher, problem-solving but the children are also adapting and problem-solving. McNiff (2002) gives an in-depth understanding of the process of action research: critically evaluate one's own practice, identify area of intended investigation, compose an action plan, implement the action plan and continue to evaluate the process.

In contrast, interpretive researchers reject the concept of developing generalisations from data and do not have the aim to improve their own practice. They see themselves as participants, but do not see themselves at the centre of the research (Bassey, 1990). Since I aimed to analyse, reflect and research my values, practice, assumptions and impact on the children in my classroom, this practice contradicts my role in the research. The focus of my research is on the enhancing of my practice and the children's learning in my classroom, therefore the interpretive approach was not a suitable approach for me.

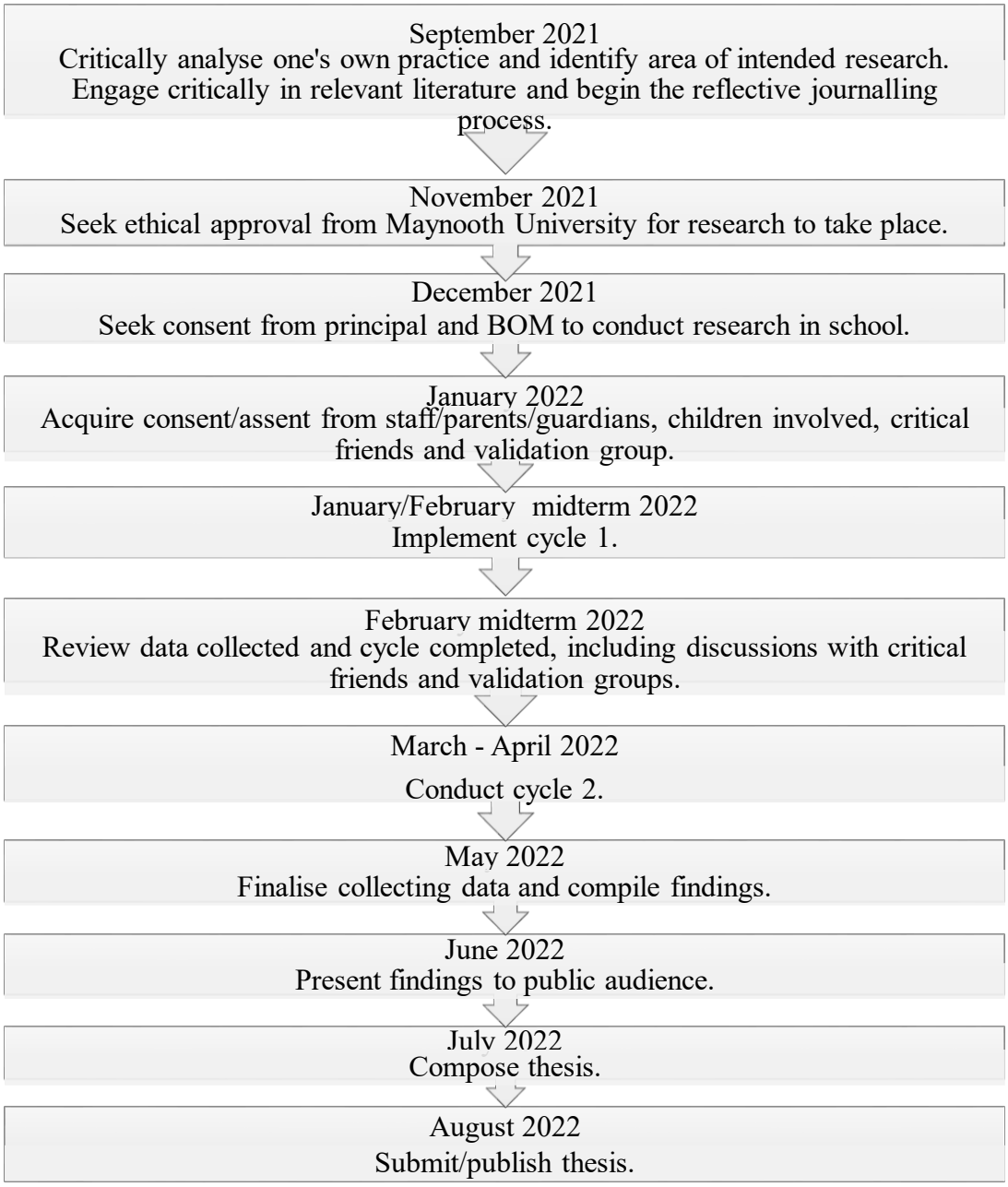
3.3 Narrative of the Research

The research was planned to be conducted over two research cycles. The cycles aimed to introduce the class to CT and teach the children to apply these skills to everyday problems. The research was completed in a mixed 1st/2nd classroom and the data sample involved the entire class. The children engaged with both unplugged and plugged activities, as discussed in Chapter 2 of this paper. The cycles consisted of two 4-week cycles and involved the children working in groups. I collected the data by means of voice recordings, observation notes, my reflective journal, children interviews and whole class discussion.

3.4 Theory and Research Plan

As mentioned previously, McNiff (2002) gives a detailed description of the systematic approach taken while completing action research. The following table lays out the process that was planned to complete the research referred to in this paper.

Figure 1 Research Plan and Time Frame



It was understood that the above timeframe could be subject to change throughout the process aligning to reflection and any unforeseen circumstances. As mentioned previously, action research is not a linear research model, it is a cyclical process and by its nature, can often be referred to as 'messy' (Sullivan et al., 2016). Any unplanned or unforeseen circumstances were recorded during the research process.

To begin this process of self-study action research an area of professional concern or interest must be identified. This can be done through reflection on one's self and one's own practice. It can also be achieved by reflecting on one's values and critically analysing if your practice is aligning to your values (McDonagh et al., 2020). During this process, I developed a deeper understanding of my values of adaptability, perseverance and particularly my values of guided discovery and child-centred learning. Throughout the initial reflecting period, I gained an insight into the children's lack of confidence when problem-solving. I quickly realised that I also lacked confidence when allowing the children to problem-solve unaided. This became the focus of my research.

The next step in self-study action research is to think critically about one's own educational practice and the practice of others through literature (McDonagh et al., 2020). The process of critically analysing the literature in the previous chapter of this paper posed as a beneficial means of exploring the different methods of introducing CT into the classroom and the benefits it provides, particularly as a problem-solving method. It also provided me with a deeper insight into the different challenges that I can present to my class. For me the literature highlighted the importance of providing children opportunities to meaningfully engage with digital technologies and develop an understanding of how to use them to problem-solve, as well as developing an understanding of the process of CT. This development of CT skills was planned to enable the children to use these techniques in a variety of situations in their lives. It also aided in the development of their confidence and enabled them to be at the focus of the learning. The meaningful engagement with digital technologies links to my value of guided discovery. The children were allowed to explore devices and 'play' with them before engaging in challenges or activities.

The next step of the process is to design an action plan, collect data and present findings. These steps will be explained in further detail throughout this chapter.

3.5 Action Plan

The below schematic provides an overview of the plan for this research and a more detailed plan of the cycles.

Figure 2 Action Research Plan

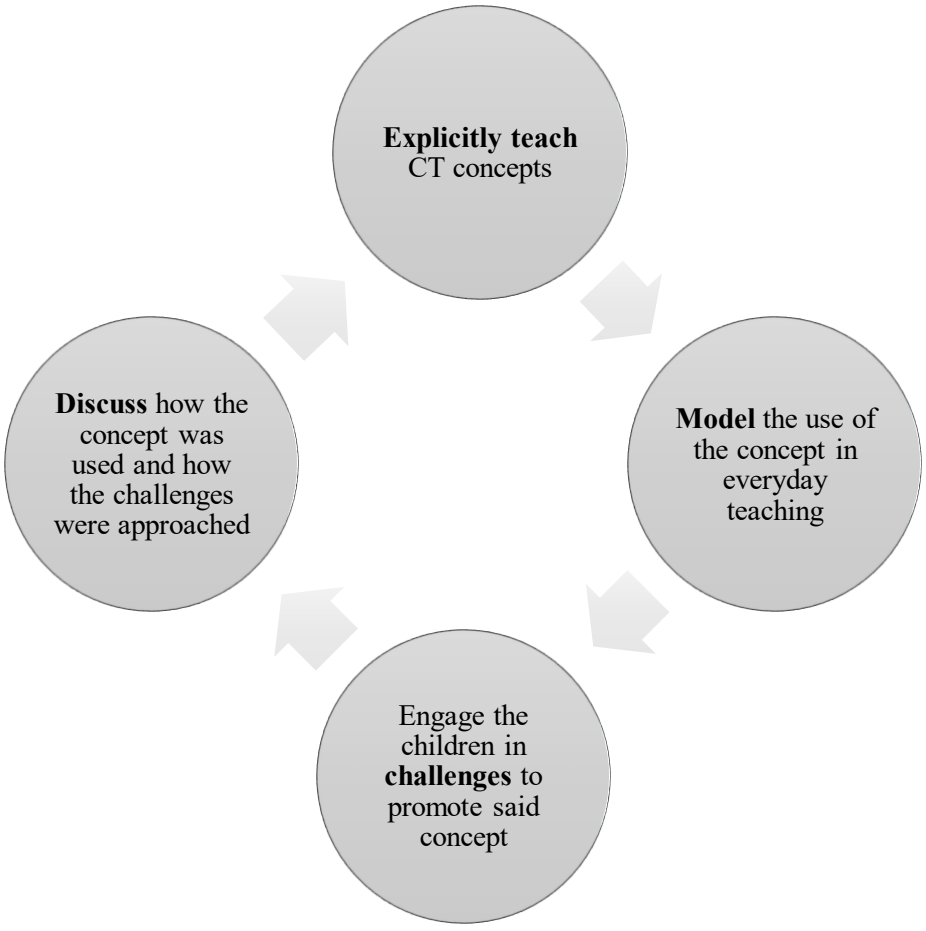


Table 1 Detailed Action Research Plan and Time Frame for Cycle 1

Date	**Cycle 1: Action Plan**
Week 1: 17th January	- The groups will be faced with a timed 'control' challenge, in groups. - A classroom discussion will be held. - The phrase Computational Thinking will be introduced to the class. - Pattern recognition will be explained, and subsequent challenges will be conducted.
Week 2: 24th January	- Algorithms and decomposition will be explained, and subsequent challenges will be conducted. - Whole class conversations will be organised to discuss findings and process.
Week 3: 31st January	- Abstraction, Evaluation, will be explained and subsequent challenges will be conducted. - Micro:bit will be introduced to the class through guided discovery. - Whole class conversations will be organised to discuss findings and process.
Week 4: 7th February	- Generalisation will be explained, and subsequent challenges will be conducted. - The class will be presented with a final set of different challenges/problems. - They will be provided with a wide range of resources in the classroom and invited to complete the challenge however they wish.

As seen in Figure 2 and Table 1, I explicitly taught the individual concepts before allowing the children to explore and develop a deeper understanding of them, following guidance from Bruner (1976) and Froebel in Tovey (2016). They talk about the importance of structure in discovery/play sessions and how it allows for a deeper understanding of the concepts being taught.

I decided to follow the Cornoldi et al. (2015) and Nunes et al. (2015) structure whereby they set a 'control' challenge at the beginning of the research to act as

comparative once the research is completed. They also designed their plan with challenges increasing in difficulty. I decided to include this also, having the more challenging concepts of CT later in the process.

A number of the unplugged challenges in Cycle 1 were inspired by the problem-solving tasks discussed by Dagiene & Sentance (2016), called Bebras. The coding challenges in Cycle 1 were introduced and posed to the class using MakeCode.

The above diagrams provide an insight into the proposed plan of implementation of Cycle 1. During the Cycle I continued to review the data collected and the children's development. I discussed this with my critical friends and validation groups and reviewed feedback given by colleagues. A number of issues were highlighted in this reflective process and the decision to design and implement a Cycle 2 was made.

Table 2 Comparison between Cycle 1 and Cycle 2

Cycle 1	**Cycle 2**
Paper-based unplugged activities to promote CT development.	Tactile, active and real-life unplugged activities to promote CT development and understanding.
Work in groups.	Choice to work in groups or individually.
Introduce Micro:bit for coding in week 3.	Introduce Botley in week 1 and Micro:bit in week 3.
Model CT during designated time allocated for challenges.	Model CT throughout the day and whenever we, as a class, face a problem.
	Encourage and praise the children's use of CT throughout the day.

As seen in Table 2, a number of changes were made to Cycle 2. Botley was introduced in Cycle 2. Botley is an introductory bot to coding (Appendix B). A bot is a device that can be programmed to do different tasks. The bot has 5 programmable buttons which allow it to be moved in different directions.

3.6 Research Instruments

As teachers, our actions are based on our own assumptions and it is essential that these assumptions are regularly examined and reflected upon (Brookfield, 2017). The most beneficial means of scrutinising and unearthing our educational assumptions is to examine them through Brookfield's four lenses: student's eyes, colleague's perceptions, personal experience and research into relevant literature. He discusses how we need to see ourselves and our practices from different angles and these lenses provide that. The data collection tools mentioned previously reflect these four lenses.

3.6.1 The student lens

Brookfield (2017) argues that the most important piece of pedagogical knowledge teachers need is awareness of our student's learning and how they are experiencing learning. This research used pupil interviews and voice recordings as a means of using this lens. Brookfield (2017) discusses how we must understand the children's experience of learning to aid them in the journey to understanding. By interviewing the children, I gained that insight and it enabled me to adapt my approach, when necessary, to aid the children's learning. Following ethical guidelines, I voice recorded the children completing the challenges. The voice recordings allowed the researcher to see

through the children's eyes without being involved. Both means were to be used and compared as it is important to be aware of acquiescence when interviewing children.

3.6.2 The lens of colleague's opinions

Critical friends play an essential role in action research and sit at the heart of the critical process. A critical friend is a person who will challenge the researcher and assess assumptions. They are open to providing different perspectives and aid in discovering new insights. If the researcher faces a problem during the research, the critical friend is there to provide support and aid. I had two critical friends, one who has an insight into my educational setting and one who does not. We organised meetings to discuss my findings and research progress. They were invited to challenge my opinions and ideas and provide an external insight into my research.

Colleagues can provide a deeper insight into the assumptions about the class. For the purpose of this research, there was a colleague in the classroom during research. Discussions with colleagues help provide a different interpretation of situations and could aid in the development of new learning. In meetings, they were invited to give me an insight into my findings and help form ideas from the data collected.

3.6.3 The lens of personal experience

A reflective journal was kept from the beginning of this research journey and was being filled in on a regular basis. This was to enhance my own reflective process and promote critical thinking on my teaching and the learning happening in my classroom. Brookfield (2017) discusses how important this lens is, since it is our own experience as learners that gives us a deeper understanding of how our children learn. As teachers, we use our personal experiences in education to mould our teaching practices. Brookfield

uses an example of finding tests difficult as a child. He used this experience to better himself as a practitioner and provide multiple forms of student assessment. By using a reflective journal, I was able to critically analyse and reflect on where my personal experience is affecting or aiding my teaching.

3.6.4 The lens of theory and literature

The process of researching literature relevant to one's topics is important as it can pose as a means of developing a deeper insight into the topic and providing guidance to the process. Literature and theory provide the researcher with the background knowledge needed to begin constructing a plan and ideas. When a researcher uncovers a piece of literature that supports their idea and articulates their beliefs, it can also be very affirming (Brookfield, 2017). The analysis of research for this paper can be found in Chapter 2.

3.7 Data Collection

The data collected in self-study is related to one's own practice and experiences. Data was collected at the beginning, throughout, and at the end of the cycle implementation, to help show development in my practice and progression in the children's understanding and implementation of CT. The collection of data was used to support my claims in newly acquired knowledge and acts as a tool to demonstrate how I aligned my practice to my values (Sullivan et al., 2016). It is important to remain aware, throughout the process, of the possibility of anticipated and unanticipated results. The data collection tools provided the necessary evidence and context for the researcher to make a valid claim to analyse, reconstruct and map their practice. Therefore, the

process of choosing suitable data collection tools is crucial. The data collection tools used for the purpose of the research were as follows: Reflective journal, observation notes, voice recordings and transcripts, group interviews and individual interviews. I also referred to and engaged with literature relevant to the topic.

3.7.1 Reflective journal

The Reflective journal was used as a means of recording my personal experience, thought process, ideas throughout the research and conversations with my critical friends and validation groups. McNiff (2016) discusses the importance of keeping notes in journals as they record your own development, reflective critique and dialectical critique as you document and interpret the reasons for your actions.

3.7.2 Observation notes

Observation notes were taken throughout the research during the challenges, the school day and on yard. I recorded conversations, behaviours and interactions between the children with each other and between the children and myself. McNiff (2016) recognises that research begins with observations, and she highlights the importance of systematically recording notes about the observations. Semi-structured observations involve gathering data with a particular focus. I used semi-structured observations as I noted the children's comments and interactions during the intervention activities.

3.7.4 Voice recordings and transcripts

Voice recordings were taken during the CT challenges and during the whole class discussions. They allow the researcher to become more aware of the process undertaken by the children during the challenges, without the teacher being present. The recording device was left on and the teacher observed from afar. By doing this, the teacher's

involvement was eliminated completely. The voice recordings provide a deeper insight into the children's problem-solving when the teacher is not present. This highlighted confidences and behaviours that may not have arisen in whole class discussions. Children were aware of the voice recording and parental permission was granted.

3.7.5 Group and individual interviews

I held group and individual interviews at the end of each of the challenges. This enabled me to identify the children's opinions, possible dilemmas and understanding. They were used to track the children's problem-solving and CT skills progress. McNiff (2016) warns that if the questions are not constructed correctly, this data tool may sometimes provide misleading data. Cohen et al. (2011) discusses questions that can be used and states that open ended questions are suitable for smaller sample groups, like this one. I used a variety of carefully constructed questions to prompt discussion and insight into the children's development (Appendix G).

3.7.6 Qualitative data

For the purpose of this research, both qualitative and quantitative data were collected. Qualitative refers to data collected that are open to different interpretations and insights (Sullivan et al., 2016). This data may provide different insights and understandings. As I believe in a more constructionist approach, the data collected for the purpose of this research was predominantly qualitative. The purpose of action research is to articulate and refine one's own professional expertise and understanding of educational practice (Vanassche and Kelchtermans 2015), which is supported by qualitative data. The quantitative data gathered was the record of the timings. These were documented for

the first and final challenge to highlight if the children became more efficient with their time.

3.8 Data Storage

The process of collecting data was aligned with/adhered to the data protection guidelines upheld in Maynooth University and in the individual school. All data collected was gathered and processed for the purpose of this research study. Digital data collected was stored and secured in an encrypted file that was password protected. Physical data collected were secured in a locked cabinet that only the teacher (myself) had access to. I adhered to GDPR guidelines with regards to data storage – Keeping all data anonymised, stored in a safe, secure and accessible form and kept for a minimum of 10 years following publication. Sullivan et al. (2016) advises that all data collected is labelled and dated correctly. Each piece of data collected for this research had a detailed and dated label.

3.9 Ethical Considerations

As the children participating in this research are under the age of 18, they are considered vulnerable persons. It was paramount to me that the research was conducted within clear ethical parameters. As a result of this, I implemented a number of risk management procedures to avoid any unforeseen circumstances and discomfort. (See Approved Ethics Form Appendix C). The parents received a detailed letter explaining the research and their child's involvement. They were asked for their written consent.

The children were given the right to informed assent in a manner that it suitable to their age and maturity. They attended a presentation explaining the research and the data collection while also receiving written notice. It was explained to the children that, if they so wish, they can withdraw from the research at any time. They were invited to give their own assent.

As I am the class teacher and the researcher, I remained aware of the power dynamics in the classroom throughout the research process and kept the issue of acquiescence in mind. As a result of this, I always ensured that I acted in a manner that respected the child's dignity and agency. BERA (2012, cited in Bucknall, 2012) guidelines state that the best interests of the child are the primary consideration. I am the children's class teacher and therefore, there was a risk of acquiescent bias. This means that the children could act in a manner that would please the teacher and their classmates. I followed Bucknall's (2012) advice on how to explain the research to the class and made sure they understood.

The context for this research, as mentioned previously, was a small rural school in which I was the 1st/2nd multigrade class teacher. An ethics form was submitted and approved before continuing with this research. Permission from the Board of Management and my principal to conduct the research in my class and school was granted in January 2022. Letters were also sent to my critical friends and participants of my validation group to gain their consent for their contribution to the research.

3.10 Validation Process

Action research has been challenged as it has the potential to be subjective (McNiff, 1995). The term self-study conjures up an idea of an individual and self-reflective approach to investigating practice. Therefore, research interactions are imperative. The interpretation and checking of data with critical friends and validation groups are a definitive aspect of the process (McNiff, 2016). These social interactions have been identified as a means of avoiding individualism and navel-gazing while concurrently allowing for a broader debate of findings and understandings (Kelchtermans & Hamilton, 2004). Collegial interactions also act as a means of triangulation of the researcher's collected and presented interpretations.

McNiff (2016) stated that a claim to new knowledge cannot be considered accurate or fair until it has been validated through triangulation. Triangulation involves gaining feedback from multiple perspectives. The validation group for this research consisted of both the staff in the school and practitioners outside of the chosen school. I met with them on a regular basis and discussed findings. They provided feedback on the research to date and helped identify any gaps. I met with the validation group regularly and discussed any possible claims to knowledge that could have been interpreted from the data at the time.

My critical friends were also consulted with throughout the process. I offered them the opportunity, throughout my research, to question and challenge my data and the accuracy of my claim to new knowledge. This acted as an outside observer triangulation as my critical friends are not in my school. I also discussed, in detail, my findings, data and rigour with my supervisor.

3.11 Conclusion

Self-study action research was chosen as it suits my professional values and the research focus; both myself and the children participating are problem-solving in the classroom. This chapter outlined the research rationale, paradigms, design, data collection methods and ethical considerations involved in this study. The next chapter will discuss the data analysis process and subsequent findings.

4. Data Analysis and Discussion of Findings

4.1 Introduction

This chapter aims to discuss and represent the findings of this research. The data discussed was collected and analysed in response to the research question posed in this paper; How might I enhance my teaching through the development of Computational Thinking (CT) as a problem-solving strategy? The crucial concept which underpinned the analysis of the data was the effect of the practitioner introducing CT into the classroom and therefore the child's ability to apply CT strategies and methodologies to different problems that were placed before them.

As mentioned previously, self-study action research was the research paradigm chosen for this paper. According to McNiff (2002), action research allows the researcher to feel a sense of ownership and accountability for their work as it is a form of professional development and self-evaluation. They are given the opportunity to analyse themselves and identify areas that could be improved or enhanced. An important aspect of this process is the ability to become a reflective practitioner, therefore meaning that the data must be evaluated and reflected upon throughout the entire process (Townsend, 2012). Throughout the two cycles- the collection and analysis of the data, I developed a deeper understanding and insight into my teaching methodology. I was able to analyse my pedagogy from different perspectives and compose a plan to modify my teaching and establish new ideas. I then implemented these plans and continued to adapt my teachings throughout two cycles.

4.2 Data Analysis

This research follows a thematic analysis approach (Braun & Clark, 2006). The data was analysed throughout the research process and a deeper analysis of the data was conducted upon completing each cycle and after the entire data was collected (Townsend, 2012). The research was conducted over two cycles. The purpose of the data analysis was to identify changes and enhancements in my practice and the impact it had on my class. This enabled me to identify evidence of my learning and my development throughout the process. Having collected and analysed data from a variety of sources, I generated initial codes for my data. A number of potential themes began to emerge once the data was coded (Braun and Clark, 2006). I analysed the themes and combined them together, leaving me with five themes before producing this report.

Table 3 Data Analysis: Themes that emerged

Themes	**Findings**
Child-Centred learning/ Self-Discovery	1. Children became more independent 2. Teacher as facilitator to learning 3. Use of resources
Child Agency in choosing group work	1. Benefits of allowing children chose groups 2. Power of your voice and opinion
Problem-solving strategies	1. Using resources around you to help solve problems 2. Persevere even if the problem looks challenging 3. Computational Thinking is beneficial throughout the day, not just at explicit times
Communication	1. Good communication is very important when problem-solving 2. Bad communication leads to frustration and misunderstandings
Confidence Development	1. Built confidence 2. Continuing to finish a task even if it was challenging

	3. Researcher's confidence in the children's ability to find answers independently improved

As a result of Covid-19, a number of children in the class were absent for a range of time periods throughout the data collection. Once completed, I began by accumulating my data and breaking it down into the groups of children that were present for both cycles and groups that were absent for long periods of time. I had not previously expected this to be an interesting aspect of my research however, I have decided to include it and will have the data separated and labelled as such below. I had also intended on analysing and comparing the girls' results to the boys'. Due to Covid-19 and the small number of girls in my class, this was not feasible.

4.3 The Control Challenge

As outlined by Threekunprapa & Yasri (2020), unplugged activities act as a scaffold to the children's learning and development of CT skills. Therefore, the focus of the first cycle was on unplugged activities with a goal of using computational devices once the children's skills had been developed. The research began with the children engaging with a challenge independently with no teacher involvement. This was to act as a control when compared to the final challenge. Observing the children during this session was interesting but also difficult for me as their teacher.

> *"I found not being able to help the children quite challenging. I wanted to help them, particularly 1st class, child 1 (CH1), 12 (CH12) and 18 (CH18)."* (Reflective Journal, 20th January 2022)

A number of children found the independent aspect of the challenge difficult. It is apparent that they had become accustomed to the teacher telling them every step of how to complete activities. During the challenge, three children decided they *"could not"* (CH12, 20th January 2022) complete it and decided to sit out. During the activity I observed the following conversation between two of the children.

"CH18: What are we meant to do? She hasn't told us.

CH9: We have to build a tower.

CH18: But how are we supposed to know how to build?

CH9: I don't know but let's try together.

CH18: I don't know how. We are going to fail."

(CH9 & CH18, 20th January 2022)

By the end of this activity, these specific children felt lost when they were left alone to complete a challenge. The following responses were given in interviews conducted after the challenge.

"I couldn't finish it." (CH15, 21st January 2022)

"You didn't help me." (CH1, 21st January 2022)

"I didn't know what to do next." (CH16, 21st January 2022)

These statements showed me that I was also a *living contradiction* (Whitehead, 2018) to my educational value of perseverance and child-centred learning. The children were not persevering and their ability to do so had not been at the centre focus in my teachings. I

had not been focusing on what they needed, so I decided to concentrate on these children for this aspect of my research.

Figure 4 2nd class tower- unsuccessful

Figure 3 1st class tower- successful

In the above two Figures, two of the towers from this initial challenge can be seen. Figure 3 shows a group of 2nd class children who invested time into building a brilliant tower but once they tested it out, the tower collapsed. This had a direct effect on their confidence as they decided to sit out of the challenge once it fell. The tower in Figure 4 was the single group in the class who built a secure tower that succeeded in the challenge. The focus of this task, however, was not on the outcome but on the process. The group succeeded but they did not enjoy the process. They found it very difficult communicating with each other and expressing their own ideas. CH3 decided to sit out of the group for a period of time and then re-join once he had *"calmed down"* (CH3, 21st January 2022). This challenge made it significantly more clear to me that the children did not have the skills that were necessary to complete these challenges independently.

4.4 Child Centred- Self-Discovery

The first theme that will be discussed is the theme of child-centred learning and self-discovery. This is one of the principal educational values that I hold and aim to see lived out in my daily practice. CT enables this within the classroom as it allows children and the teacher to develop the skills and confidence they need to uncover and understand new learnings independently (Kale & Yuan, 2021). When the children are solving problems and *tinkering* their solutions to the best of their ability, they have more freedom to investigate new ideas and explore deeper (Zaharin et al., 2018). As the facilitator in the classroom, I provided the children with clear learning intentions and a variety of different resources to construct solutions and to enable them to become active learners.

I have explored how CT skills can be introduced into the classroom through plugged or unplugged activities. Both Dagiene & Sentance (2016) and Zaharin et al. (2018) discuss the benefits of these two methods, and I had planned to explore both options. In my experience, using different approaches to do the same tasks suits different children's needs, and I aimed to focus on all the children in my research.

4.4.1 The Unplugged Challenges -Cycle 1

The Bebras (Dagiene & Sentance, 2016) tasks were used at the beginning of Cycle 1 to introduce the concepts of CT to the class. Each week a new concept of CT would be explicitly taught, and the children would then engage in tasks in groups. In theory, these tasks were perfect for this research, as they were designed to be completed independently. It quickly became apparent that the children were finding these challenges too difficult.

"The class seem to be finding the Bebras tasks too challenging. They are not recognising the CT skills. Need to include more active tasks in Cycle 2."

(Reflective Journal, 24th January 2022).

The children were engaging with the tasks and completing them, but it did not seem as though they were discovering anything new in them. When finishing an abstraction challenge and posed with the question 'What did we learn today?' I received the following answers from the class:

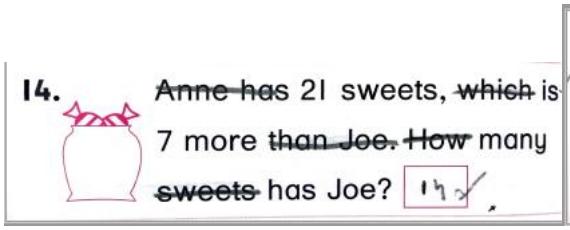
"*I don't know."* (CH12, 27th January 2022)

"*Breaking things down makes them easier." (*CH11, 27th January 2022)

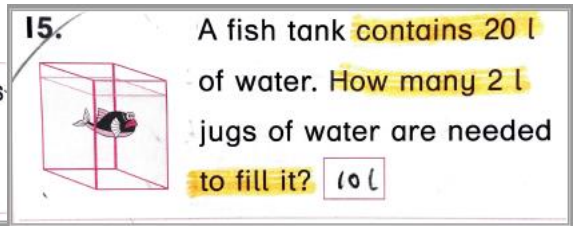
"*That we can underline the important words." (*CH16, 27th January 2022)

While I could see that the children were developing CT skills, I did not believe these challenges were proving beneficial as they were not carrying the concepts forward from session to session.

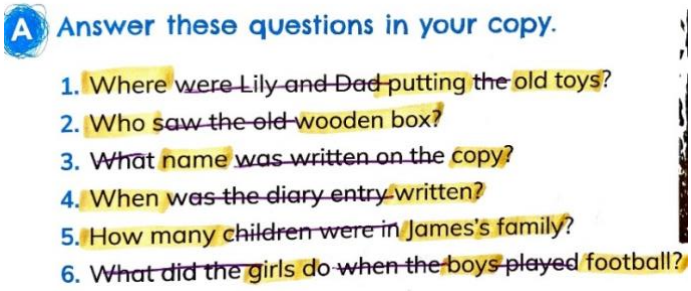
While completing problem-solving activities outside of our 'Challenges time', I noticed a number of children using CT to decompose and abstract their questions.



(CH17, Mental Maths, 28th January 2022)



(CH9, Maths, 31st February 2022)



A Answer these questions in your copy.

1. Where were Lily and Dad putting the old toys?
2. Who saw the old wooden box?
3. What name was written on the copy?
4. When was the diary entry written?
5. How many children were in James's family?
6. What did the girls do when the boys played football?

(CH13, Literacy, 2nd February 2022)

Figure 5 Three samples of CT

This was unprompted by the teacher and proved to me that the class were capable of more than I was facilitating. I did not realise the children would make the skills cross-transferable independently. This was one of the many factors, which I will discuss later in this chapter, that prompted me to begin planning Cycle 2. It was clear that the children were learning CT skills but that they weren't benefitting fully from the process. Upon reflection, I also believed that it was quite teacher-led and was not allowing for the children's own discovery.

4.4.2 The Unplugged Challenges - Cycle 2

I believed that the children would benefit from more active activities, such as the ones explained by Zaharin et al. (2018). They explained that CT activities do not need to be explicitly taught and can be introduced through unplugged games and active challenges. I used the example of 'Simon Says' and noticed the children immediately using their CT (Zaharin et al, 2018). The next set of challenges were more active and allowed the groups to move around the classroom while solving their problems. This proved more beneficial as they were able to develop their own answers in creative and unique ways. Each group took different findings away from the sessions. When I asked the class the question *"What did you learn?"* I got a different set of answers.

"I was able to pick the important parts and get (CH1) to do that part because they are good at it. It made it quicker." (CH6, 3rd March 2022)

"I didn't know we could do it like that. I got to try new ways of building." (CH13, 4th March 2022)

"We made a plan, and I gave everyone instructions on their part. I learned that I was good at that." (CH5, 3rd March 2022)

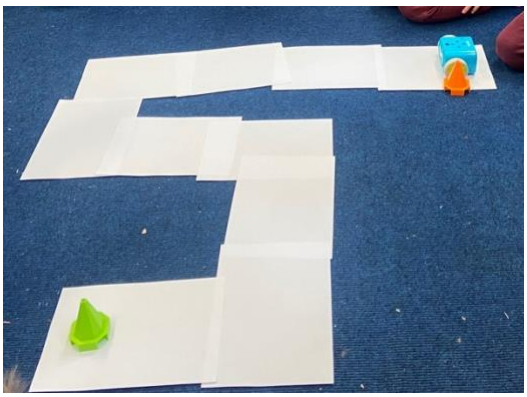
It is also clear from the above that the class were happier and enjoying the process more than the previous challenges. This shift to a focus on a self-discovery approach to the unplugged challenges made a huge impact on my research. I had not expected the class to benefit from it as I had not reflected on my own teaching enough to realise that I was a living contradiction (Whitehead, 2018). The children were happier, more engaged and developed more skills through this approach than in Cycle 1.

4.4.3 Plugged- Botley

In Cycle 1, the plan was to introduce Makey Makey and Micro:bit once the children were confident in their use of CT in the unplugged challenges. Makey Makey is an invention kit that involves using circuits and a computer. However, once I switched the focus to a more self-discovery approach, I decided to include Botley in the process. Botley is a small introductory bot. It has a remote control and codable buttons to instruct the bot to move. While completing the unplugged challenges, the children were also given a time slot where they could design, create and complete challenges with Botley. The class completed these challenges in their groups.

While observing the children designing and completing these challenges, I noticed their development increasing from session to session. At the beginning, they

were building courses that were easy to complete. As the sessions went on, they developed a deeper understanding of how Botley moves and how difficult they could make the course.



(Sample Challenge, 28th February 2022)

(Sample Challenge, 3rd March 2022)

Figure 6 Sample Botley Challenges

The children succeeded with all of the Botley challenges and developed their CT skills in the process. They then partook in the unplugged challenges above and moved onto Micro:bit.

4.4.4 Plugged- Micro:bit

The 2nd class had experience working with Micro:bit last year with me. The 1st class had no previous exposure to the coding platform. As Berry (2013) explains, the exploration technique, when using computational devices with children and teenagers, is beneficial and promotes CT in the process. By giving our students the code they need, we are not promoting problem-solving or CT. From my experience, children have a more meaningful learning experience when they make discoveries about coding themselves.

The children were given time to explore the coding platform themselves and to work out how to complete different challenges. It was evident in the first session that the 1st class were more eager to explore, and the 2nd class were trying to remember how they had completed challenges last year. This left the 1st class benefiting more from the first session as they were testing out different blocks. When I asked the groups what they did in the session, they gave me the following responses.

> *"I tested out all of the blue blocks to see what they did."*(CH3, 15th March 2022) 1st class
>
> *"I wanted to test music like you did last year. But I didn't have time to get it to work. Can I test it next time?"* (CH17, 15th March 2022) 2nd class
>
> *"We were trying to remember how to do the dance."* (CH9, 15th March 2022) 2nd class

Once the children had all been given an opportunity to explore the resources available, I began setting them different challenges. The groups were allowed explore and design a solution themselves. At the beginning of these challenges, I found it difficult not to get involved but as the cycle moved along, I found it easier. I caught myself coming up with solutions to the posed problems that I hadn't thought of before while observing the children. As the teacher, it was a huge learning moment for me. I experienced the benefits of taking a step back and allowing the children explore independently.

> *"Today was brilliant. I observed CH12 explore Micro:bit and come into his own. I was so proud and wanted to congratulate him but knew it would disturb his progress. He discovered how to do the problem by testing out the buttons and explaining them to the group."* (Reflective journal, 15th March 2022)

4.4.5 Final challenge

In the final challenge, the children were invited to complete a challenge that incorporated their unplugged CT skills and their digital literacy. The class were posed with the challenge and given access to a wide range of resources. During this challenge, the children were confident and eager to test their solutions repeatedly until it worked. When asked what they were doing next, one group said: *"We are going to pick up everything and start again. That one didn't work but now we know the paper is too thin"* (CH11, 28th March 2022). The group tested 3 new builds until they found one that worked. The whole class was interviewed when the challenge was finished:

> *"We worked it out with no help."* (CH14, 29th March 2022)
>
> *"That was fun. We tried loads of different ways to build it."* (CH13, 29th March 2022)

It is evident from these statements that the children enjoyed the independence of exploring the challenge themselves. There were only two children who approached the teacher to ask for support. The class were eager to get involved and break down the challenge in their groups and see what they could do with the resources available to them.

4.4.6 Reflection

Throughout this self-study action research journey, I filled in a reflective journal, which I have made reference to above. I filled in the journal on a regular basis where I critically reflected on my teaching and how closely I was aligning my practice to my values. This was to heighten my practice and the children's learning in the classroom (Sullivan et al., 2016). I was focusing on my value of active discovery and a child-

centred approach. Upon beginning this research, I believed I was following these values strongly. However, once I began to critically analyse my practice during Cycle 1, I realised I was not. Cycle 2 allowed for a stronger focus on this value and therefore more development.

4.5 Child Agency

The next theme that became apparent while analysing the data collected in the classroom is that of child agency. Children deserve their voice and opinions to be heard and taken into consideration in the classroom. The importance of active and discovery methods of teaching is explained in the 'Introduction to the National Primary School Curriculum'. This allows the children to explore and become active agents in their own learning, creating new opportunities and wonder (NCCA, 1999). This also resonates with my value of child-centred learning and independence.

4.5.1 Group work

While planning for this research, I viewed myself as the facilitator; allowing the children to explore and investigate the resources before engaging with the challenge. I designed Cycle 1 to be completed in pods, due to Covid-19. However, I discussed this and the Cycle 1 findings with my critical friends and they gave the following feedback:

> *"Could you consider, allowing the children to choose if they complete the challenge individually or in groups? This would allow for more choice with the children. Some of the children may thrive on their own."* (Critical Friend, 5th February 2022)

I then analysed my data again and recognised how the children had made comments about being in groups.

"Can I just do it on my own?" (CH6, 24th January 2022)

"We have to stay in our groups?" (CH10, 27th January 2022)

I then decided to focus on this while planning Cycle 2, as seen in Table 2. The children were allowed to decide if they wanted to complete the challenges alone or in groups. This limited the number of questions I was receiving, and I noticed less frustration in the classroom while completing the challenges. I observed a number of children initially decide to complete the challenges alone, but quickly rethink their decision and request to join a group. This therefore allowed the children to appreciate their groups and understand how beneficial they could be.

"I thought I wanted to be alone, but I want to go back." (CH3, 3rd March 2022)

"I want to be alone, but I want to be alone with 'CH6'. Can I do that?" (CH7, 8th March 2022)

"I think I want my group back now." (CH1, 8th March 2022)

I also found it interesting to note that the children who requested to be alone and then changed their mind were all in 1st class, while the children in 2nd class did not do this.

There were two children who elected to complete a selection of the challenges alone and they thrived in those sessions. Both children were in 2nd class. They completed their work in less time and made the following comments.

"I like working on my own. It helps me think." (CH16, 14th March 2022)

> *"I just had a different idea to them that I wanted to do."* (CH17, 24th March 2022)

They decided to work with the group in different scenarios but enjoyed the choice. When asked *'What do you think about being able to choose to do the work on your own or in a group?',* they gave the following response.

> *"I like it because I'm able to decide what I wanted to do alone. But then sometimes I feel like working with my friends. It is fun."* (CH6, 29th March 2022)

> *"It is weird because we aren't usually allowed but I like it because I sometimes have different ideas to other people, and I get to try them out."* (CH10, 29th March 2022)

This was a slight change to my practice that allowed two children to feel more comfortable and happy completing activities. It gave them more control over their work and allowed them to explore and experiment with their own ideas.

4.5.2 Value of voice

Another finding I discovered was the power of voice. A number of the children tried working alone but the majority decided to continue working in groups. An interesting observation I made in my journal was about CH3.

> *"I've seen CH3 try and build on his own, but he always keeps an eye on the group he was with. He regularly goes back and gives the group advice on how to better their build. Also, his build is always different to theirs."* (Reflective Journal, 3rd March, 2022).

In Cycle 1, this child was observed sitting out of the challenges, upset, because *"no one was listening*" to them (CH3, 24th January 2022). They wanted to participate but didn't know how to be heard in the group. When interviewed at the end of Cycle 1 about the process he said *"I'm not needed in the group. They do fine without me*" (CH3, 3rd February 2022). This was difficult for me, as an educator with values of a child-centred approach to learning, to hear. I brought this concern to my critical friends who advised me.

> *"Observe him on yard and in other tasks throughout the day and see if they are acting the same way. If yes, intervene because it may not be related to CT or your research."* (Critical Friend, 10th February)

I continued to observe the child while they were engaging in other activities in the classroom and on yard. I realised that this attitude towards his own voice and opinions was only when he was problem-solving and not throughout the day. This highlighted to me that he did not understand the effect his opinions would have on the problem-solving tasks. He began working on his own and completing the challenges independently, but it was clear, when observing, that he wanted to be in the group. I wanted to intervene and encourage him to work on the tasks, but I understood that it would disturb the CT process. When teaching the CT concepts to the whole class, I began making reference to the importance of breaking problems down, delegating and focusing on strengths, as a means of indirectly encouraging him to work with his friends and understand his worth to the group. As his confidence grew, he began to understand that he could advise the other groups and have his opinions heard. He began by talking to different groups while they were problem-solving and talking about their

solutions. During the final challenge, he then made the decision to work in the group and when interviewed said: *"They needed me, we worked as a team"* (CH3, 28th March 2022).

4.6 Problem-solving Strategies

As the use of problem-solving strategies were part of the initial concern of this research, it was also discovered as a theme in the data. Developing a child's problem-solving skills is critically important in education as it affects their everyday lives (Keen, 2011). In 1960, Jerome Bruner referenced the importance of education and how its purpose is to facilitate children's problem-solving skills and individual thinking in order for them to be transferred and utilised in a variety of different situations. The initial concern that sparked this research was around problem-solving skills and therefore it was crucial that I observe the children's interactions with problems. I designed the challenges and decided to compare the children's strategies before I had introduced and modelled CT in the 'control' challenge and in the final challenge.

4.6.1 Problem-solving in the initial challenge

There were five groups working on the challenge and they approached the problem in a variety of ways. Group one, as seen in Figure 3, grabbed the resources and immediately began building without discussing what they were doing or compiling a plan. They all began adding different pieces to the tower without communicating with each other. Their tower eventually collapsed, and they did not engage with the problem further.

> *"Just grab everything you can find, and we can stick it on. That'll make us win"*
>
> (CH11, 20th January 2022)

Group two, who had previous experience with CT and remembered the importance of planning, decided to draw their plan on a piece of paper before getting resources. Once they began building, however, they did not refer back to the plan. They tested out their tower and when it collapsed, they tried again.

> *"Remember what Ms Tighe said last year, we have to plan. I'll draw this and we can build then."* (CH14, 20th January 2022)
>
> *"Let's just stick it all together using these, and it'll work."* (CH13, 20th January 2022)

Groups three and four found it very challenging to begin.

> *"Ms Tighe, I don't know what we are doing."* (CH18, 20th January2022)
>
> *"What do we do?"* (CH10, 20th January 2022)

Both groups decided to look at other tables and build similar towers. Group five, as seen in Figure 3, built an excellent tower. However, they found the process very challenging. Each member of the group wanted their opinions to be heard and they were all attempting to build the tower at the same time.

> "*CH1: We could put these here to make it straight.*
>
> *CH6: Maybe not, these are better because they are strong.*
>
> *CH1: But these are really strong too, see?*
>
> *CH3: I've an idea of what we could use, why don't we-*
>
> *CH1: You have to listen to me. We have to work together."*
>
> (CH1, CH6, CH3, 20th January 2022)

The children did not have the necessary problem-solving skills to approach the challenge independently. This highlighted to me the importance of teaching these skills in the classroom. Referring back to Voskoglou (2016), if they cannot solve problems in a controlled environment, how can they be prepared for challenges they will face later in life?

4.6.2 Development of problem-solving skills

During Cycle 2, I modelled the use of different resources and demonstrated the importance of trying out different items to see if they could help with solving the problem. For example, when teaching about Spain in Geography I asked the children *'How could we find out where Spain is?'.* As a class, we then discussed the different resources we had in the school to help solve our problem- 'Where is Spain?'. We discussed how we could use an atlas, our class map on the wall, the internet and ask older classes. The children recognised how using different resources could benefit the solution to our problem and how some of them would give us an answer quicker than others.

> *"I was modelling the importance of using the resources around us today in class and they seemed to understand it. I'm looking forward to tomorrow's challenge to see if they carry this new understanding forward."* (Reflective Journal, 15th March)

The next day the children were posed with a challenge where they were to design a maze and guide their blindfolded partner through it. I observed the children using a variety of resources around the classroom to help them plan their maze and their instructions. CH9 decided to use Botley. They built the maze using pieces of paper on

the table and then coded Botley to complete the circuit. Once they had the code completed, they used the code they had inputted into Botley, to give instructions to their partner using 'big steps'. During the final challenge, the children appeared to be happier and more engaged. They were more comfortable solving the problem and working together to do so.

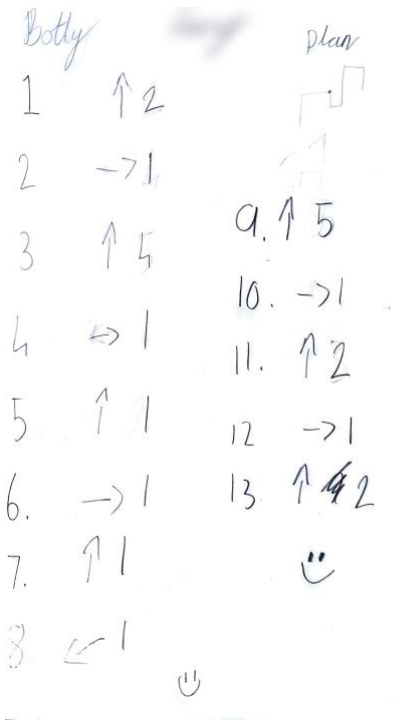


Figure 7 CH9 Plan for challenge

When asked why they were using Botley, CH9 gave the following response: *"I want to be able to test out my answers again and again without having to ask (CH14) to move. I'm pretending Botley is (CH14) and one move is one big step."* (CH9, 8th March 2022).

Another example of the children independently problem-solving is related to our art lessons. When completing art involving paint in the classroom, the children are asked to clean the tables when finished to remove any paint residue. The children decided to solve the problem of the tables getting dirty and use the resources available

to them, without my input. Due to Covid-19 the children have individual plastic boxes for their books. A number of children in the class independently made the decision to complete their artwork on the lids of their waterproof boxes. By doing this, they would only have to run their box lid under the tap to clean it, as opposed to cleaning the entire table. This demonstrated to me their growing confidence in problem-solving and that their independence was flourishing. They identified a problem, broke it down, found a solution and implemented it without my involvement.

The children also became more efficient with their time when completing their challenges. In the initial session the class took 40 minutes to complete their build. In the final challenge, the children took 25 minutes. The final challenge had more elements than the initial one, but the children had developed the necessary skills to break their problem down and focus on the important parts.

4.6.3 Development of CT outside of challenges

The children's development of CT became more apparent as the challenges progressed. As seen in Figure 5, the children began integrating their CT skills into their work throughout the day. They began to understand that the skills were transferable and could be used outside of the challenges and the classroom. At first, they began crossing out words in their work to better understand the questions and by the end of the cycle, they were openly discussing how the questions could be broken down to be better understood. A number of the children continued to do this with their written work for the remainder of the year, including their standardised tests.

> *"The children have been continuing to use their CT skills when completing written tasks. They even used them today in their standardised tests and their*

results are all brilliant. I even compared the 2nd class results this year to their results last year and it has really benefited them academically." (Reflective Journal, 27th May 2022).

I also observed the children actively using their CT skills on yard. I observed the following conversation.

"CH9: Why do we have this problem every single day when we play pets?

CH13: I don't know. Maybe we should just play a different game.

CH15: But I don't want to. I like pets.

CH9: Right. Let's do what Ms. Tighe does and problem-solve. Look for a pattern, what happens every day that we don't like. Then we can look at that to see if we can find a solution.

CH13: Okay. Well, we always pick who is on first then pick our pets.

CH15: Yea. I like being the cat.

CH9: Okay so today, why don't we pick pets first and then pick who is on? That okay CH15, you can still be a cat?

CH15: Okay.

CH13: Sure."

(CH9, CH13, CH15, 30th March 2022)

Though I do not understand the rules of the game *'pets'* the children were playing, this showed to me that the children understood the importance of problem-solving correctly

and looked at the bigger problem to identify a ‘bug’. They identified the ‘bug’ in their game and used it to begin finding a solution and continue playing the game.

4.6.4 Reflection

From the above, I can see that the children have developed a good understanding of the importance of using problem-solving strategies and use the concepts of CT as a means of beginning the process. When reflecting on this, I can now see how beneficial it is for me to not engage when the children have an initial problem. I believe it is important for me to observe and allow the children to begin finding a solution themselves and if intervention is needed, only then do I join the conversation. This realisation was difficult for me as it mirrors most of my values: child-centred learning, perseverance, guided discovery. I realised that I wasn’t living as closely to them as I had thought. I do now, comparatively, have a deeper understanding of my values and their benefits in my classroom.

4.7 Communication

The importance of good communication was an aspect of this research I did not realise would be of such significance and was revealed as a theme in the data. When analysing my data, I recognised the effect that this process had on the children’s ability to communicate when problem-solving and also the effect bad communication can have on the problem-solving process.

During the initial control session, the children in group five found communicating their ideas to each other challenging, as discussed previously. I recorded this interaction:

"*CH1: We could put these here to make it straight.*

CH6: Maybe not, these are better because they are strong.

CH1: But these are really strong too, see?

CH3: I've an idea of what we could use, why don't we-

CH1: You have to listen to me. We have to work together."

(CH1, CH6, CH3, 20th January 2022).

The children were speaking over each other and were not valuing the importance of listening to everyone's opinion. As mentioned, CH3 decided to sit out of the challenge as a result of this. I noted this and decided to make reference to the importance of listening throughout the week. During the next challenge, I decided to observe this group particularly, focusing on their communication skills. I did not notice a difference and made the decision again to discuss listening as a whole class. During one of the succeeding challenges, I noted the following conversation.

"CH6: Okay let's take turns saying our ideas.

CH1: Yea but you have to listen to me this time.

CH6: Okay we will listen and try it.

CH7: Fine. We can listen and try all of them."

(CH6, CH1, CH7, 3rd March 2022)

It was clear that the children were reluctant to try this but once they began listening, they became more excited. They began to understand how everyone can benefit from listening and talking to each other.

The children in group two also found it difficult communicating their ideas to each other. In the control session, they made a plan but did not follow it. They were excited and became completely focused on the building process and not their plan. Although their lack of communication did not impact their building process directly, it had an impact on their final 'solution'. They all had brilliant ideas when making the plan but when they began building, they did not decide which idea they were focusing on and therefore did not follow the plan. They did not communicate what each person was doing, and they were all just adding different pieces without discussing it.

In the final challenge, this group decided to stay working together. They had developed an understanding of how to break problems down into more manageable pieces, through CT and decided to delegate. They split the problem into different parts and gave everyone a role.

> *"CH13: Okay, let's do this. I'm good at drawing so I will draw our bridge and the plan. CH12, you're the best at coding so you can make the alarm and CH14, you're great at sticking the bits together so you can do that.*
>
> *CH14: And when you're done those bits you can come help me because I can't do it alone.*
>
> *CH13 &CH14: Okay."*
>
> (CH12, CH13, CH14, 28th March 2022)

This highlighted to me as a teacher that I may need to focus on the teaching of good communication skills in the future, as it allows the children to gain a greater

benefit from group work. It enables them to develop more skills as they are able to communicate their ideas and opinions.

4.8 Confidence Development

Another significant theme that was uncovered was the development of confidence. When reflecting on my practice, my own and the children's confidence were highlighted to me as a concern. I aimed to build and develop our confidence, primarily when problem-solving. As discussed by Yurtseven et al. (2021), a person's self-esteem and confidence has a direct impact on their problem-solving skills. Without the confidence to try out different ideas to come to a solution, the process is going to be very challenging. Upon reflecting on Cycle 1, the development of the children's confidence became even more important to me.

4.8.1 Confidence in the children

As discussed, a number of children decided to sit out of the initial challenge. One of those children was CH12. CH12 is a child in my class who has low self-esteem and finds regulating his emotions when problem-solving challenging. He gets frustrated when he did not solve the problem immediately and give up. During the first challenge, he was part of group one that tried to build their tower but when it collapsed, they decided not to try again. CH12 made the decision to not partake in a number of challenges after this in Cycle 1 but always watched his group closely. He slowly began taking part, and in Cycle 2 he quickly developed a very good understanding of CT. As his understanding of CT developed, so did his confidence when problem-solving. I observed him plan a number of solutions to problems and test out each one before

finding the most suitable. His confidence development was particularly apparent during a Micro:bit coding challenge.

> *"Today was brilliant. I observed CH12 explore Micro:bit and come into his own……He discovered how to do the problem by testing out the buttons and explaining them to the group."* (Reflective journal, 15th March 2022)

As he was part of the group that had worked with Micro:bit last year, he immediately went onto the coding platform and began pulling out blocks from memory. When they did not work, I watched him get frustrated, clenching his fists. This time, however, he calmed himself down, cleared the blocks from the coding canvas and tested every block individually to develop a better understanding of what they did. This gave him a better understanding of Micro:bit and he was then ready to solve the problem correctly. Since that session, I have watched his confidence grow when problem-solving throughout the day. He now uses CT when completing written challenges and when out on yard.

4.8.2 Confidence as a practitioner

At the beginning of this research cycle, I did not have confidence in my practice. I felt as though I could improve my practice and therefore improve the learning experience my class were having. Throughout the reflective process and the implementation of CT, I have developed that confidence. I recognise how I was not living closely to my professional values and understand how I can do so now. I have developed an understanding of the learning experience my class have and know how it benefits them. I now have enough confidence in myself as a practitioner to understand that I can step back from a situation and observe the children solve problems independently and only

intervene when needed. I have confidence in my class completing work independently and developing skills through guided discovery.

4.9 Impact of Covid-19

As mentioned previously, Covid-19 had a significant impact on this research. As a large number of the class were missing in Cycle 1, I decided to reflect and begin planning Cycle 2. This was not necessarily a negative impact as it forced me to reflect on my findings in Cycle 1 and realise that my class were not benefiting or developing as I had planned. There were also a number of children who missed the initial control challenge and a significant amount of the process. I have taken a sample of these children and represented the potential impact the absenteeism had on their progress.

Table 4 Covid impact

Child and Class	**Process**	**Final Challenge**	**Time missed**
CH 17 2nd class	- Previous exposure to and passion for CT - Eager to get involved and 'catch up' - Decided to work independently - Demonstrated great understanding of CT in challenges and in classroom - Used CT in written work and on yard	- Decided to work independently - Demonstrated great understanding of CT - Enjoyed the process	-Initial Challenge -Significant amount of Cycle 1
CH 7 1st Class	- Eager to catch up - Loved challenges - Found communication	- Found group work challenging but didn't want to work independently	-Initial Challenge -Significant amount of

	challenging - Developed understanding quickly - Eager to use in work outside of challenges	- Demonstrated great understanding of CT - Lack of confidence	Cycle 1
CH2 1st Class	- Uninterested or engaged	- Uninterested or engaged	Majority of research
CH14 2nd Class	- Virtually completed challenges at home, at request - Eager to use in every aspect of the day - No impact on CT development	- Low impact - Engaged very well - Demonstrated great understanding of CT	2 weeks of Cycle 2

4.10 Conclusion

This chapter has discussed the data analysis process and the subsequent findings for this research. The themes from my data have been detailed and discussed: Child-Centred learning/ Self-Discovery, Child Agency, Problem-solving strategies, Communication and Confidence Development. The data collected answered the question: *Can the introduction of CT as a problem-solving strategy enhance my practice?* The next chapter will summarise the research and consider recommendations for the introduction of CT into the classroom.

5 Conclusion

5.1 Introduction

This study examined the potential benefits of introducing computational thinking (CT) as a problem-solving strategy into a primary classroom and the benefits of explicitly teaching problem-solving strategies outside of the mathematics curriculum. To capture the changes that occurred within my practice as a teacher, the action research methods of data collection and analysis were employed. The overall aims of the study were to develop confidence in myself and my students when problem-solving, live closer to my professional values and examine the benefits of CT as a problem-solving strategy. The data collected throughout the process provides evidence that CT *was* beneficial to my class and that I am now living closer to my values of perseverance, adaptability, guided discovery and child-centred learning. This chapter will provide a summary of the findings and discuss the implications of the research and also map out suggestions for future practice.

5.2 Summary of Findings

This research revealed to me how CT as a problem-solving strategy can have a huge impact on a class. It showed the benefits of explicitly teaching problem-solving strategies outside of the mathematics curriculum and the advantages of focusing on a child-centred and guided discovery approach to teaching. Enacting this child-centred approach, whereby the pupils were constructing their own knowledge and exploring their own ideas, allowed the children to develop confidence and a sense of agency. The children became more independent and developed a deeper understanding of the

resources available to them. They learned the power of their own voice and the effect their opinions can have on a group. The class enhanced their problem-solving skills and learned to persevere when a challenge seemed ‘too difficult’. Both the researcher and the children achieved an understanding of the impact of good communication when problem-solving.

This research process enabled me to experience the true benefits and necessity of reflection as a professional. Previously, I would not have taken moments to formally reflect on my practice in the classroom or events that happened in school. Allowing myself this time to think and reflect on myself, what went well in a lesson, what did not go well, how the children responded etc., allowed me to develop a deeper understanding of how the children in my class were experiencing learning. It enabled me to make the necessary adjustments to enhance their experience and learning. It also allowed me to see how critical I am of myself and recognise how I deal with challenges I face in the school setting. This research has instilled a confidence in me and my practice. I have recognised how I was not living as closely to my values as I had expected to and implemented changes to adjust that. I plan on continuing this practice in my years of teaching. I will continue to reflect on myself as a practitioner and realign my practice if I ever lose focus of my values. I will continue to model CT as a problem-solving strategy and hope to explore the explicit teaching of other strategies and their benefits in the future.

5.3 Limitations to the study

Participant bias is a potential limitation when conducting research, particularly when working with children. Children can adapt their behaviours and answers as a means of pleasing the teacher researcher and giving them the answer they are looking for (Farnsworth, 2019). This was highlighted to me early on in the research when CH18 approached me asking what I wanted them to do (CH18, 20th January 2022). The child was trying to do what I, the teacher and researcher, wanted them to do. I recognised that this could have been also due to a lack of confidence in their ability. To overcome this, I reminded my class about the importance of telling the truth and also about the confidentiality of the research. Before beginning the subsequent challenges, I explained to the class that I would not be upset by their efforts in their constructions or their answers and that being honest was more beneficial to help me learn.

Another limitation in this research was the Covid-19 pandemic and classroom restrictions. A number of my class were out at various times throughout the research and therefore I had limited children who were present for the whole process. I had planned on focusing on gender, comparing 1st/2nd class and the different groups I had formed. However, due to the classroom restrictions we had in place in my school and the absenteeism, I was unable to do so.

The lack of computational devices in my school was also a limitation. As we are a small rural school, we do not have a wide variety of devices for our classes at all times. I overcame this by having the children work in groups or take turns when coding on the computers. I also ensured no other classes were online at the same time as we were so as to ensure the broadband was clear.

An additional limitation was the lack of variety in problem-solving strategies. CT was the chosen strategy and I believed it was the most beneficial to my class who had not been exposed to a wide variety of digital devices before. I recognise that there are an expansive number of strategies and that children should be exposed to a variety of them during their time in school. There were two children in my class who did not show much progression throughout the process. There was no disadvantage for them participating in the study and they did show a deeper understanding of problem-solving by the end. However, it is possible that a different strategy may have been of more benefit to them. I plan on exploring other strategies, for example the Kipling method, in the future and comparing the benefits of them to CT. The Kipling method (1902) highlights six important questions that are used to help construct a solution to any problem – who, what, when, where and how.

5.4 Development of Theory and Recommendations

This study enabled me to understand the expansive benefits of teaching problem-solving skills and focusing on CT in the classroom. It also highlighted to me the lack of focus on problem-solving skills in the current curriculum and the effect that this has had on my class. The children in my classroom learned to make sense of the problems they were facing and develop strategies to overcome them or stop them occurring again. It is a common misconception that CT is explicitly taught using 'plugged activities' and therefore, schools without these resources do not engage in CT activities. This research has shown how CT can be developed using teacher modelling, unplugged challenges and limited technology. I make no claim that my findings can be generalised for every

teacher's classroom, though I hope this study will make teachers more aware of the simplicity of introducing CT and the benefits of doing so. I also hope that this study highlights to teachers how important it is to explicitly teach problem-solving strategies.

CT as a problem-solving strategy remains a new concept in education in Ireland and it was difficult to compare my findings to other studies in an Irish primary school context. In 2019 the NCCA published a report on an initiative introducing CT into Irish schools. This report resulted in coding and CT being mentioned in the draft curriculum (NCCA, 2020). It provides a good insight into how to integrate CT using coding and as a means of promoting digital literacy but does not focus on the long-term benefits of CT as a means of problem-solving. Through the use of unplugged activities, I believe that CT can be integrated into more classrooms around Ireland that may not have access to digital devices. My research is limited as it was conducted on a small scale but does show the benefits of introducing CT as a problem-solving strategy across the curriculum, as discussed in chapter 4. I believe that the NCCA pilot scheme in 2019 should be redesigned and reimplemented, focusing on problem-solving skills and the transferability of CT across the curriculum. In light of the draft curriculum (NCCA, 2020), this research could then be used in third-level teaching colleges to promote the importance of these skills and the simplicity of integrating them into the classroom across the curriculum. When studying my Bachelor of Education degree in Dublin City University, I specialised in digital technologies and spent time learning about CT. CT was only briefly mentioned in the compulsory modules of the degree. If it was taught as a problem-solving methodology, teachers would have the foundation understanding of the concepts to then implement it into their own classrooms. For qualified teachers, in-service training should be provided to show the benefits of CT and how it can be

integrated using both plugged and unplugged activities. Organisations such as the Professional Development Service for Teachers (PDST) could run courses on how to promote CT as a problem-solving strategy or create a toolkit for teachers. This toolkit could include links to different activities to use in their classroom, for example, links to free resources such as Scratch or Bebras. or courses to complete to upskill.

I firmly believe every school should focus on a whole school approach to problem-solving as a life skill. I am not making a claim that CT is the best method of problem-solving, nor am I claiming that it is the only strategy that should be taught. I am only hoping that my integration of it can show other teachers how transferable of a skill it is, particularly with our students living in a digital-rich era, and how important it is to teach these skills. This claim is supported by the draft curriculum (NCCA, 2020) where problem-solving is listed as a primary focus.

5.5 Conclusion

This research has been extremely beneficial to me as a researcher and as a teacher. I have developed a deeper understanding of myself, my class, my values and the benefits of reflection. I now understand the lack of focus in teaching problem-solving strategies and what I can do to enable the students in my classroom to develop their own problem-solving strategies. I believe I can enable the children in my class to face problems with confidence, and to persevere when things become challenging.

This research has sparked an interest in agency and highlighted to me how it can affect children when they are problem-solving. I hope that this research can benefit others in the future, allowing for further research into agency in problem-solving. As

this is an area I would like to further explore, I look forward to building on this paper. I aspire for this research to benefit research into problem-solving strategies in the future. This new academic year, I will be teaching 5th and 6th class and look forward to introducing CT to an older age group.

Finally, when I discuss my research with colleagues and friends, I am constantly reminded of the children in my class and how some of them grew considerably. I watched them use their new skills in their work unprompted and watched them convince themselves to try again when they failed. I think of this entry in my reflective journal:

> *"Today was brilliant. I observed CH12 explore Micro:bit and come into his own. … He discovered how to do the problem by testing out the buttons and explaining them to the group. I am full of pride."*
>
> (Reflective journal, 15th March 2022)

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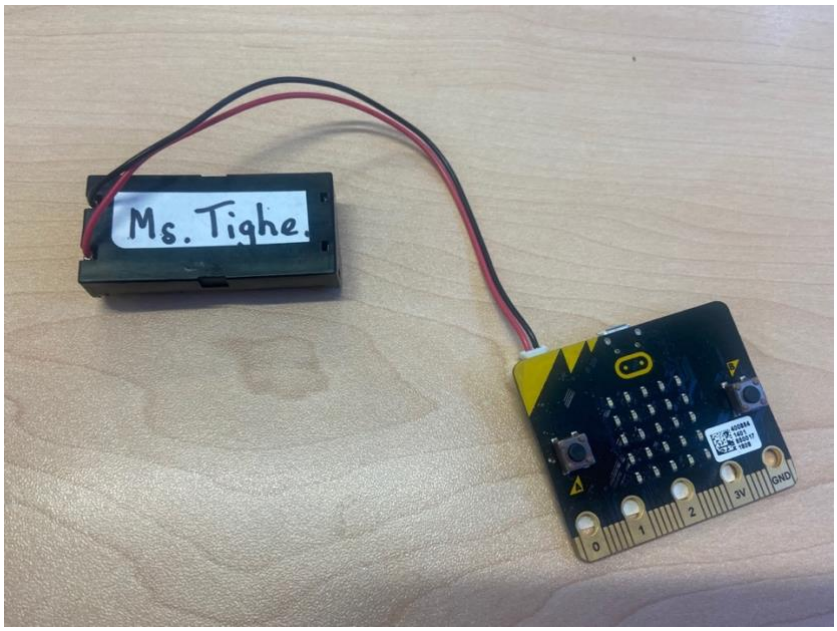
Appendices

Appendix A Micro:Bit



Appendix B Botley

Appendix C Approved Ethics Form

Maynooth University
National University of Ireland Maynooth

Maynooth University
National University of Ireland Maynooth

Froebel Department of Primary and Early Childhood Education
Master of Education (Research in practice) (MEd)

Ethics Approval for Master of Education (Research in Practice)
(Please read the notes in the course handbook before completing this form)

Student name:	Caoilinn Tighe
Student Number:	21251827
Supervisor:	Tony Sweeney
Programme:	Master of Education (MEd): Research in Practice
Thesis title:	Action Research Thesis: Enhancing my teaching through the development of computational thinking as a problem-solving strategy.
Research Question(s):	How might I enhance my teaching through the development of computational thinking as a problem solving strategy.
Intended start date of data collection:	January '22
Professional Ethical Codes or Guidelines used:	Maynooth University Ethical Guidelines

1(a) Research Participants: Who will be involved in this research?

Participants/group (*tick all that apply*)

Early years / pre-school	
Primary school students	✓
Secondary school students	
Young people (aged 16 – 18 years)	
Adults (Critical Friend)	✓

Provide a brief description of the individuals and their proposed role in your research below [Max 50 words]:

This research will be taking place with 20 1st/2nd class children. The class will be engaging in different activities to promote the development of computational thinking. Their approach to solving different challenges will then be observed to note the problem-solving strategies being used. The classroom SNA will be working alongside the pupils she is assigned to. My critical friend will challenge me to think critically about my research.

1(b) Recruitment and Participation/sampling approach: *How will these participants become involved in your research? What type of sampling is involved? Please describe the formal and informal recruitment processes? Please describe the type of participation and level of engagement of participants? Are there gatekeepers and what is their part of sampling process? [Max 100 words]*

The sampling approach I will be using is *Purposive Sampling*, whereby I am choosing the audience I work with. The children will be invited to participate in the research through both formal and inform means: formal being written context and informal being oral explanation. Each child will be invited to partake in different challenges/activities to help develop their computational thinking. They will then be invited to solve different problems using said techniques. Consent will be obtained from the children's parents. Other staff members within the school will also be involved in my research. These staff members will be acting as critical friends and will critique my ideas and give me feedback on my research. The gatekeepers to this research are my principal and the BOM, both of whom will be formally approached for consent.

2. Summary of Planned Research (*please indicate anonymised location type, purpose and aims of research, research questions and design, methods to be used and time frame, process of analysis) [250 words]*

I plan on exploring the benefits of introducing Computational Thinking (CT) as a problem-solving strategy in my teaching. I will monitor and take note of the children's approach to each challenge and compare how these methods change as they learn more about and develop CT. I hope to find that the children learn to preserve and use the equipment available to them to solve challenges posed to them. I hope to see them decomposing questions, recognising patterns and creating algorithms.
I will be using self-study action research as my methodology of research. This means I will be analysing and reflecting on my practice, focusing on my values of perseverance and adaptability. The research will be conducted alongside children from a multigrade, rural setting in 1st and 2nd class. I plan on collecting my data through a number of different means; reflective journal, anecdotal notes taken during challenges, interviews with children, surveys conducted, and notes from meetings with staff members. This data will be majority qualitative and with minimal quantitative. I will be conducting my research in phases where I slowly introduce CT to my class through the means of unplugged activities (STEAM) and computational challenges. I will be taking notes on the classes approach to each challenge and conducting surveys to note their confidence levels. I will keep copies of all these notes and also the interviews conducted with the children.

The children will be engaging with the research throughout the process. My critical friend will be less involved as they will only be approached sporadically throughout.

3. Ethical Issues: Please outline the main ethical issues which may arise while undertaking this research. *Outline the nature of consent and assent about participants. (You should discuss these concerns and outline the responses/supports you will provide in the boxes below)*

The children will be given the right to informed assent in a manner that it suitable to their age and maturity. They will attend a presentation explaining the research and the data collection while also receiving written notice. It will be explained to the children that, if they so wish, they can withdraw from the research at any time. As I am the class teacher, I will remain aware of the power dynamics in the classroom throughout the research process and keep the issue of acquiescence in mind.

Vulnerability *(minimising risk, discomfort, coping with unforeseen outcomes, can any aspect of the research give rise to any form of harm to participants, including the researcher)?) [Max 100 words]*

As the children participating in this research are under the age of 18, they are considered vulnerable persons. As a result of this, I will implement a number of risk management procedures to avoid any unforeseen circumstances and discomfort.

- I will explain the purpose of the research to the class through an oral presentation. The children can then, with the guidance of their parents, give their consent.
- I will avoid any activities or comments that I believe could result in negative outcomes for the child.
- I will protect the child's self-esteem and ensure I ask questions that are appropriate to the child's level. If an issue is to occur, I will meet confidentially with the child and/or parent.

Outline the potential for increased risk to participants considering changing circumstances in the school environment because of immediate closure or threat to privacy or anonymity. Consider implications for a change or changes in methodological tools (virtual formats). [Max 50 words]

In the event of a change of circumstance in the school environment ie. moving to a virtual setting, the research will be conducted via secure, encrypted video conferencing software. As the nature of my research is digital, the method will not change drastically. Data will be collected virtually and stored in an encrypted format and the children will engage with activities virtually.

Power dynamics *(between researcher-participants, amongst participants, insider-research, reflexivity, gatekeepers, working with your colleagues, working with students, etc): [Max 100 words]*

Considering the age of the children partaking in this research, I must be aware of the power relations. As a result of this I must always ensure that I act in a manner that respects the child's dignity and agency. BERA, 2014 guidelines state that 'the best interests of the child are the primary consideration…'

I am the children's class teacher and therefore there is a risk of acquiescence bias. This would be where the children act in a manner that would please the teacher and their classmates. I will follow Bucknall (2012) advice on how to explain the research to the class and ensure they understand.

Informed consent and assent *(for participants - and guardians where appropriate. Please also note any other approvals that may be required from other bodies (i.e. Board of Management.): [Max 100 words]*

Permission will be sought from the Board of Management, School Principal, fellow staff members, parents of the children involved in the research and the children themselves. The children will be given the right to withdraw assent at any time in the research process. Participants will be given anonymity in writings and all data will be stored in a secure location. Their identity will be kept confidential through the use of pseudonyms and numbers ie. Child 1. The location of my research will also remain anonymous and will not be noted anywhere within my research.

Consider if consent of participants may need to include a list of any new scenarios/situations that may be required for data collection activity in light of school closures or short-term illness of school members (teachers/SNA) and how this may impact the research. Outline below; [max 50 words]

In the case of an emergency closure, the research will be conducted via video conferencing. The data will be collected in the same manner. The children will complete the tasks virtually and their problem strategy techniques will be observed via video conferencing. The video conferencing will take place on a secure, password protected application. When obtaining consent/assent, this will be explained.

Sensitivity *(topics that may be potentially sensitive, intrusive or stressful, have you considered what to do in relation to dealing with the aftermath of a sensitive disclosure? how do you intend to deal with unexpected outcomes?) [Max 100 words]*

The nature of my research does not show any predictable harm or disadvantage. Everyday teaching will still occur, with new activities introduced. These activities will be familiar to 2nd but will be new to 1st. I will take the time to explain the changes to introducing them and I will explain that the class may withdraw from the research, if they so wish.

There may be children who find the type of learning challenging. I will ensure to prepare for this when planning my activities.

As a researcher I may be under statutory duty to disclose confidential information to authorities. If this is to occur, I will seek advice.

Data storage *(where will the findings be stored; will they be potentially published in future? And by whom?) [Max 100 words]*

The digital data collected will be secured in an encrypted file that will be password protected. Physical data collected will be secured in a locked cabinet that only the teacher (myself) has access to. I will adhere to GDPR guidelines with regards to data storage – Keeping all data anonymised, stored in a safe, secure and accessible form and kept for a minimum of 10 years following publication.

This project may be published in acknowledged academic journals or books in the future. If so it will be approved by the university and my supervisor.

Declaration *(Please sign and date)*

'I confirm that to the best of my knowledge this is a full description of the ethical issues that may arise in the course of undertaking this research.' If any of the conditions of this proposed research change, I confirm that I will re-negotiate ethical clearance with my supervisor.

Signed:_ 

03/11/21

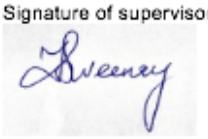
Supervisor use only:

Date Considered: 18/11/2021

(*Tick as appropriate*)

Approved	Y
Approved with recommendations (see below)	
Referred to applicant	
Referred to Department Research and Ethics Committee	

Signature of supervisor:



Department use only: *(only where applicable)*

Date Considered: _____

Approved by Froebel Department Research and Ethics committee	Y
Approved with recommendations (see below)	
Referred to applicant (changes to be approved by supervisor)	
Referred to Maynooth University Social Research Ethics Subcommittee	

(*Tick as appropriate*)

Recommendations:

Signature of Dept. Ethics Committee Chair: _____

Approved by Froebel Department Research and Ethics committee	
Referred to applicant (changes to be approved by supervisor)	

(*Tick that apply)*

Maynooth University Social Research Ethics Subcommittee use only *(only where applicable)*

Date Considered: _____

Signed:

_____
FSS Research Ethics Committee nominee

Checklist for students

Please complete the checklist below to confirm you have considered all ethical aspects of your research. **(Note that the consent form/s, assent form/s and information sheet/s that must accompany this application will be scrutinised and any omission or inadequacy in detail will result in a request for amendments).**	**Please tick**
I have attached (an) proper consent form/s, assent form/s and/or information sheet/s	✓
Each form and sheet is presented to a high standard, as suitable work carried out under the auspices of Maynooth University	✓
Each consent form has full contact details to enable prospective participants to make follow-up inquiries	✓
Each consent form has full details, in plain non-technical language, of the purpose of the research and the proposed role of the person being invited to participate	✓
Each consent form has full details of the purposes to which the data (in all their forms: text, oral, video, imagery etc) will be put, including for research dissemination purposes	✓
Each consent form explains how the privacy of the participants and their data will be protected, including the storage and ultimate destruction of the data as appropriate	✓
Each consent form gives assurances that the data collection (questionnaires, interviews, tests etc) will be carried out in a sensitive and non-stressful manner, that the participant has the right to cease participation at any time and without the need to supply a reason	✓
Please include here any other comments you wish to make about the consent form(s) and/or information sheet/s.	✓

Reference:

Bucknall, S (2012), Children As Researchers in Primary Schools: Choice, Voice and Participation, Taylor & Francis Group, London. Available from: ProQuest Ebook Central. [17 November 2021].

Appendix D Invitation Letter to Research Participants

Consent Forms

Maynooth University Froebel Department of

Primary and Early Childhood Education

Roinn Froebel Don Bhun- agus Luath- Oideachas

Ollscoil Mhá Nuad.

Dear Parent(s)/Guardian(s),

I am a student on the Master of Education programme at Maynooth University. As part of my degree, I am doing a research project. The focus of my research is based on Computational Thinking as a problem-solving strategy.

In order to do this, I intend to carry out research in the classroom by inviting the class to engage in a range of different activities and solve a number of problems.

The data will be collected using observations, a daily teacher journal, photographs, voice recordings and pupil feedback forms. In the event of a school closure, data will be collected via Zoom classes/SeeSaw. The children will be asked their opinions through discussing how they found the different challenges at the beginning of the research and how they find them at the end.

The child's name and the name of the school will not be included in the thesis that I will write at the end of the research. Your child will be allowed withdraw from the research process at any stage.

All information will be confidential, and information will be destroyed in a stated timeframe in accordance with the University guidelines. The correct guidelines will be complied with when carrying out this research. The research will not be carried out until approval is granted by the Froebel Department of Primary and Early Childhood Education.

I would like to invite you and your child to give permission for him/her to take part in this project.

If you have any queries on any part of this research project, feel free to contact me by email at Caoilinn.Tighe.2022@MUMAIL.ie

Yours faithfully,

Caoilinn Tighe

(Child's name) …….

I am trying to find out how children learn how to solve problems in different ways. I would like to learn more about this. I would like to watch you and listen to you when you are in school and to write down some notes about you. If the school closes, we will talk over Zoom.

Would you be okay with that? Pick a box

Yes **No**

I have asked your Mum or Dad or Guardian to talk to you about this. If you have any questions, I would be happy to answer them. If you are happy with that, could you sign the form that I have sent home?

If you change your mind after we start, that's ok too.

Caoilinn Tighe 21251827

Maynooth University

Froebel Department of

Primary and Early Childhood Education

Roinn Froebel Don Bhun- agus Luath- Oideachas

Ollscoil Mhá Nuad.

PARENTAL CONSENT FORM

I have read the information provided in the attached letter and all of my questions have been answered. I voluntarily agree to the participation of my child in this study. I am aware that I will receive a copy of this consent form for my information.

Parent / Guardian _____

Parent / Guardian Signature_____

Date: _____

Name of Child _____

Child's signature: _____

Date: _____

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Childhood Education

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agus Luath- Oideachas

Ollscoil Mhá Nuad.

Information Sheet

Parents and Guardians

Who is this information sheet for?

This information sheet is for parents and guardians.

What is this Action Research Project about?

Teachers on the Master of Education in the Froebel Department of Primary and Early Childhood, Maynooth University are required to conduct an action research project, examining an area of their own practice as a teacher. This project will involve an analysis of the teacher's own practice. Data will be generated using observation, reflective notes and questionnaires. The teacher is then required to produce a thesis documenting this action research project.

What are the research questions?

- How might I enhance my teaching through the development of computational thinking as a problem-solving strategy.

What sorts of methods will be used?

- Observation, Reflective Journal, Questionnaires, voice recordings, pictures etc
- In the event of a school closure, data will be collected via Zoom/SeeSaw

Who else will be involved?

The study will be carried out by myself, Caoilinn Tighe, as part of the Master of Education course in the Froebel Department of Primary and Early Childhood Education. The thesis will be submitted for assessment to the module leader Dr Bernadette Wrynn and will be examined by the Department staff. The external examiners will also access the final thesis.

What are you being asked to do?

You are being asked for your consent to permit me to undertake this study with my class. In all cases the data that is collected will be treated with the utmost confidentiality and the analysis will be reported anonymously. The data captured will only be used for the purpose of the research as part of the Master of Education in the Froebel Department, Maynooth University and will be destroyed in accordance with University guidelines.

Contact details: Caoilinn Tighe **E:** Caoilinn.Tighe.2022@MuMail.ie

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Ollscoil Mhá Nuad.

Child's assent to participate

My parent/guardian has read the information sheet with me, and I agree to take part in this research.

Name of child (in block capitals):

_____

Signature: _____

Date: _____

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Ollscoil Mhá Nuad.

Declaration by Researcher

This declaration must be signed by the applicant(s)

I acknowledge(s) and agree that:

a) It is my sole responsibility and obligation to comply with all Irish and EU legislation relevant to this project.

b) I will comply with Irish and EU legislation relevant to this project.

c) That the research will be conducted in accordance with the Maynooth University Research Ethics Policy.

d) That the research will be conducted in accordance with the Maynooth University Research Integrity Policy.

e) That the research will not commence until ethical approval has been granted by the Research and Ethics committee in the Froebel Department of Primary and Early Childhood Education.

Signature of Student: 

Date:

Appendix E Sample challenges from first cycle

Logic

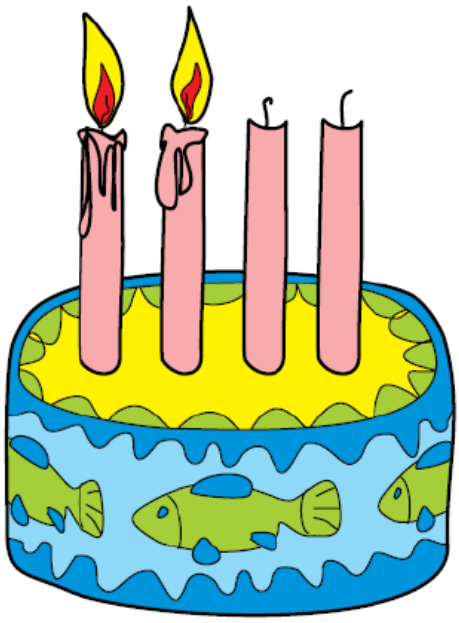
Beaver birthday

14

There are only two numbers in Beaverland: 0 and 1.

Count in Beaverland:

0 →	0000
1 →	0001
2 →	0010
3 →	0011
4 →	0100
5 →	0101
6 →	0110
7 →	0111
8 →	1000
9 →	1001
10 →	1010
11 →	1011
12 →	1100
13 →	1101



During a birthday celebration burning candles means 1 and unlit means 0.

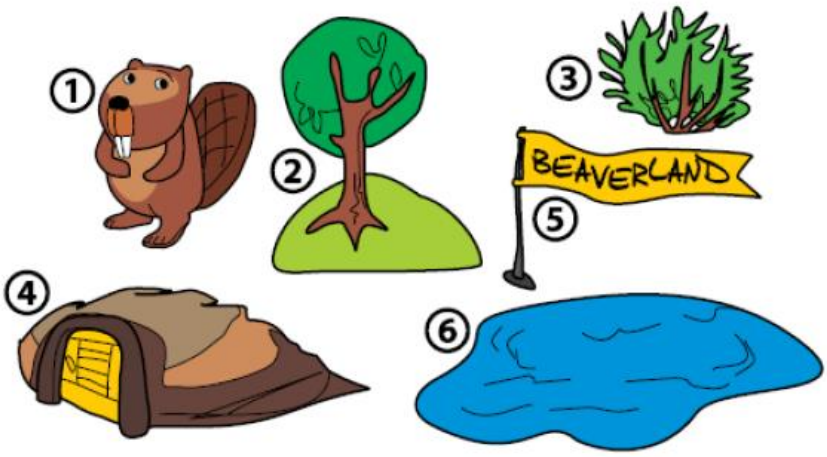
How old is the beaver?

Algorithms

Layered painting

4

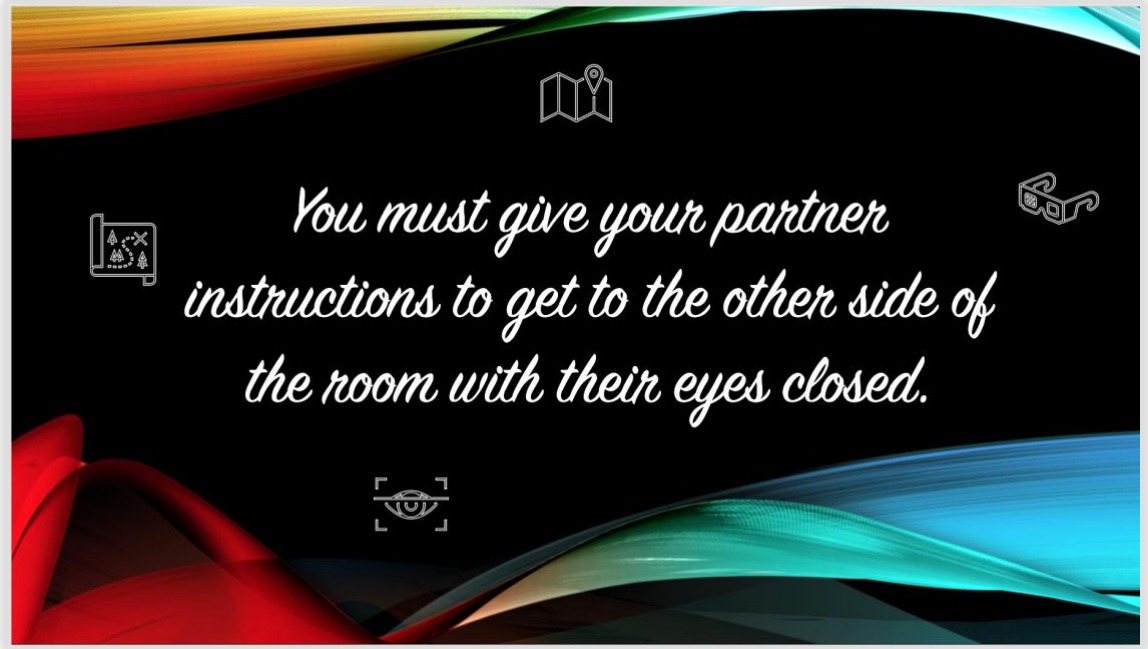
Little beaver has six stamps.



By using these stamps, he created a painting:

In what order did little beaver use the stamps?

Appendix F Sample challenges from second cycle



Appendix G Sample questions asked at the end of each challenge

Questions used in whole class discussion and in individual interviews.

Questions- Whole Class/Individual

- What did you think of the challenge?
- What did you learn today?
- How did you solve the problem?
- What did you do on your own?
- What did your group do?
- How did you work together?
- Did you have fun?
- Did you find it easy or hard?
- Why did you do it like that?
- What do you think of ___ group?
- If you could do it again what would you change?
- Would you have liked more time?

Appendix H Sample questions asked during the challenges

Questions during challenges

- What are you doing?
- What are you doing next?
- Do you have a plan?
- Who is doing this part?
- What did you do first? Why?
- Why did ____ do this?

Appendix I Sample transcripts of individual conversations

CH1, CH6, CH3, 20th January 2022

CH1: We could put these here to make it straight.

CH6: Maybe not, these are better because they are strong.

CH1: But these are really strong too, see?

CH3: I've an idea of what we could use, why don't we-

CH1: You have to listen to me. We have to work together.

CH15, 21st January 2022

Teacher: What did you think of the challenge yesterday?

CH15: It was hard. I couldn't finish it.

CH1, 21st January 2022

Teacher: Hey CH1, what did you think of the challenge yesterday?

CH1: You didn't help me at all. Why didn't you help me?

Teacher: I wanted to see if you could do it yourself.

CH1: You didn't help me.

CH16, 21st January 2022

Teacher: What did you think of the tower challenge yesterday?

CH16: It was confusing.

Teacher: Why do you think it was confusing?

CH16: I didn't know what to do next. You usually tell us what to do next.

CH3, 24th January 2022

Teacher: Hey CH3, what's wrong?

CH3: This is too hard.

Teacher: What is?

CH3: The group. No one was listening to me when I was talking. I have good ideas, but they won't listen to me.

CH3, 3rd February 2022

Teacher: How have you found the challenges we have done?

CH3: The group is hard.

Teacher: How is it hard?

CH3: I'm not needed in the group. They do fine without me.

Teacher: I don't think that is true. I think we need to make sure you are heard next time. Okay?

CH3: Okay.

CH6, CH1, CH7, 3rd March 2022

CH6: Okay let's take turns saying our ideas.

CH1: Yea but you have to listen to me this time.

CH6: Okay we will listen and try it.

CH7: Fine. We can listen and try all of them.

CH9 & CH14, 8th March 2022

Teacher: Hey, how is it going over here?

CH9: Good

CH14: Great

Teacher: What are you doing?

CH14: I'm getting ready to go.

CH9: I'm making the instructions.

Teacher: How are you making your instructions?

CH9: With my best friend Botley.

Teacher: He is your best friend. Why are you using Botley?

CH14: We love him!

CH9: I want to be able to test out my answers again and again without having to ask (CH14) to move. I'm pretending Botley is (CH14) and one move is one big step.

Teacher: Why are you doing that?

CH9: It just makes sense in my head, it's easier.

CH12, CH13, CH14, 28th March 2022

CH13: Okay, let's do this. I'm good at drawing so I will draw our bridge and the plan. CH12, you're the best at coding so you can make the alarm and CH14, you're great at sticking the bits together so you can do that.

CH14: And when you're done those bits you can come help me because I can't do it alone.

CH13 &CH14: Okay.

CH3, 28th March 2022

Teacher: How do you find your group now?

CH3: This time?

Teacher: Yes. How do you find working with them now?

CH3: They needed me, we worked as a team. I had fun. I think they know how to listen now. Thank you.

Teacher: That's great CH3.

CH6, 29th March 2022

Teacher: Hey, are you okay?

CH6: Yep, yep

Teacher: Are you choosing to work on your own?

CH6: Yea

Teacher: What do you think about being able to choose to do the work on your own or in a group?

CH6: I like it

Teacher: Oh really? Why?

CH6: I like it because I'm able to decide what I want to do alone. But then sometimes I feel like working with my friends. It is fun.

Teacher: That's great.

CH10, 29th March 2022

Teacher: Hey, how are you doing over here?

CH10: Good. Is this okay?

Teacher: Is what okay?

CH10: That I'm working over here by myself?

Teacher: Sure, is that what you want?

CH10: Yea. I want to be alone for a bit.

Teacher: That's okay. What do you think about being able to choose to do the work on your own or in a group?

CH10: It is weird because we aren't usually allowed but I like it because I sometimes have different ideas to other people, and I get to try them out.

Teacher: Would you like to have the choice more often?

CH10: Yea, that would be cool. Can we?

Teacher: Sure.

CH9, CH13, CH15, 30th March 2022

CH9: Why do we have this problem every single day when we play pets?

CH13: I don't know. Maybe we should just play a different game.

CH15: But I don't want to. I like pets.

CH9: Right. Let's do what Ms. Tighe does and problem-solve. Look for a pattern, what happens every day that we don't like. Then we can look at that to see if we can find a solution.

CH13: Okay. Well, we always pick who is on first then pick our pets.

CH15: Yea. I like being the cat.

CH9: Okay so today, why don't we pick pets first and then pick who is on? That okay CH15, you can still be a cat?

CH15: Okay.

CH13: Sure.