"Bee-Bot only speaks Irish."

*A s*ociocultural investigation of the use of programmable floor robots for second language learning and developing computational thinking skills in the early years of primary school.

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Declaration

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Abstract

This thesis presents a sociocultural theory (SCT) investigation of the use of robotics for second language learning (SLL) and computational thinking (CT) skills development in the early years of primary school. The research intervention combines a playful storytelling robotics-based activity with the Irish language within a play session.

Jeanette Wing, revived the area of CT in (2006, p. 44) noting that CT should be added "to every child's analytical thinking." Current research indicates that technological tools have a positive impact on the development of CT skills when integrated with other curricular areas in primary school (Alimisis & Moro, 2016; Angeli & Valanides, 2020; Angeli et al., 2016; Bers, 2020; Bers et al., 2012; Hassenfeld & Bers, 2020).

This research intervention contributes to the field of CT skills development as well as second language learning in the early years of primary school, through the integration of robotics and Irish, in an English medium classroom. The researcher deemed design-based research (DBR) as the most appropriate methodology to answer the research questions while using both qualitative and quantitative data collection methods. The research intervention was developed through an iterative design cycle of two one pilot cycles and a third pilot cycle over six weeks. The final iteration, cycle four, comprised of a six-week intervention using Bee-Bot (programmable floor robot) as part of a playful activity to promote second language learning with 22 children in a junior infant class (aged 5-6 years). The children worked in small groups to programme Bee-Bot to support their storytelling through Irish.

The results of this research activity were positive with feedback from the children and the teacher of increased interest and use of the Irish language, observed language gains; identification and development of CT skills; and positive meaningful engagement through Irish amongst the children.

The findings provide an insight into the opportunities that a technological tool provides during a playful activity with this young age group as well as outlining the potential parallels between the language learning process and CT skills development. As the Irish curriculum moves towards a more integrated model (NCCA, 2023) the analysis of the children's experiences during this research activity along with their language and CT skill development offers an interesting insight for early year's language educators and curriculum developers in Ireland.

Summary

This thesis presents a sociocultural investigation of the use of robotics for second language learning and computational thinking (CT) skills development in the early years of primary school. Research indicates the positive impact that technological tools present to the development of various curricular areas in primary school including the development of CT skills (Bers, 2020). Jeanette Wing revived the area of CT noting: "Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability*,"* (Wing, 2006). Defining CT and the specific skills associated with it has been widely contested and while researchers report CT skills and their application across domains, a solid grounding in the area is still lacking.

The research reported here aims to address the use of a robotics tool for second language learning while also exploring CT skills that are developed in the early years of primary school. There has been a lot of interest in the integration of technological tools or devices in the early years of primary school for development of CT skills and coding as a literacy skills (Bers, 2018b). With technological tools such as robotics, children can explore various curriculum areas including language learning through playful and engaging activities. A play-based activity was developed which incorporated the target language and storytelling from the children's Irish language lessons. Through assigned tasks, the children navigated Bee-Bot along the route of the storyline, collaborating with each other through Irish and developing their CT skills.

This research activity followed an iterative design cycle based on the Design-Based Research model (Wang & Hannafin, 2005). Three pilot studies were conducted with a boys' senior infant class and a girls' senior infant class, both aged 6-7, for a one-day intervention each and a third pilot cycle over a six week period in a co-educational senior infant class. These pilot cycles focused on different aspects of the research design, including children's questionnaires, gathering assent, activity setup, and activity design. The feedback from the pilot cycles, along with the insights from focus groups with the children, influenced the development of the main research cycle (Nic Réamoinn & Devitt, 2019).

In the fourth research cycle, a co-educational junior infant class was involved in the study over a period of six weeks. The language learning activity was conducted with 24 children aged 5-6. The children played in groups directed by the teacher, using Bee-Bot to navigate through the story from their language lessons. Data collection for this cycle included questionnaires, video analysis, focus group interviews, a teacher interview, and feedback.

Both quantitative and qualitative methods were employed to analyse the data, using descriptive statistics and thematic analysis. The results of this intervention were positive, showing increased motivation to use the language, language gains, the emergence and development of critical thinking skills, and positive meaningful engagement in the Irish language among the children. The research results shed light on the potential benefits of incorporating technological tools in playful activities for young children. The comprehensive qualitative analysis of children's experiences, language learning, and development of computational thinking skills presented in this thesis holds significant value for language educators and curriculum developers in primary education, not only in Ireland but also in other contexts.

By conducting thematic analysis of activity interactions and engaging in focus group interviews, this study captures the children's perspectives regarding various factors influencing their engagement with the activity and their views on using robotics in learning the Irish language.

These findings can contribute to future planning and curriculum design, particularly when it comes to integrating digital tools to foster second language development at the primary level. The recommendations resulting from this thesis could support broader initiatives aimed at enhancing Irish language education during early primary years. Ultimately, this research seeks to promote the Irish language as a dynamic and living means of communication and develop computational thinking skills.

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Abbreviations

CAL	Coding as Another Language
CLT	Communicative Language Teaching
CT	Computational thinking
DBR	Design Based Research
EAL	English as an Additional Language
LO	Learning Outcome
MKO	More Knowledgeable Other
NCCA	National Council for Curriculum and Assessment
PLC	Primary Language Curriculum
PTDF	Positive Technological Development Framework
SCT	Sociocultural Theory
SLA	Second Language Acquisition
SLL	Second Language Learning
CHILDES	Child Language Data Exchange System
UNCRC	United Nations Convention of the Rights of the Child
ZPD	Zone of Proximal Development

1 Introduction

This thesis presents a research intervention that combines a playful storytelling robotics-based activity with the Irish language within a play session conducted in the early years of primary school. Despite the challenges encountered in teaching the Irish language in primary schools, this research investigates the use of robotics as a playful approach to enhance oral language development in children's second language learning.

This introductory chapter provides an overview of the rationale for the study, the context in which the thesis is situated, the aims of the study, and the research questions that will guide the investigation. Furthermore, a summary will be provided for each chapter of the thesis.

1.1 Rationale

This research intervention is motivated by my experience as a primary school teacher in Ireland, where I developed an interest in using technology to support second language learning.

The research intervention takes place in a junior classroom in an English-medium primary school in Ireland, where Irish is taught as a second language. The children in this class, aged between 4 and 5 years, are the focus of this study. In this educational context, the Irish primary curriculum includes ten subjects from the Primary School Curriculum (1999) and includes two languages, Irish and English. The Primary Language Curriculum (PLC) (2019) encourages an integrated approach to language teaching, promoting skill transfer between the two languages. In this research intervention, Bee-Bot, a floor programmable robot will be introduced as a playful device to facilitate second language learning during a play session.

According to Harris et al., 2006, English-medium schools often face challenges in providing meaningful opportunities to effectively use the Irish language. Through the integration of Bee-Bot, the children will collaboratively engage in storytelling in Irish while concurrently developing computational thinking (CT) skills as they interact with the robot on a floor mat. The intervention aims to assess the impact of Bee-Bot on increasing language usage frequency among the children and explore the interconnection between CT skills development and second language learning. Furthermore, the research will investigate the sociocultural constructs which support the children's learning process during this intervention.

The findings from this research intervention may contribute valuable insights to educational practices, informing educators and policymakers about innovative ways to support language learning and technology integration in early years' classrooms.

1.2 Thesis context, Aims and Research Questions

This section will provide an overview of the study's context and aims, along with the research questions that will guide the study.

1.2.1 Thesis context

The Irish language is the national and first official language of Ireland in accordance with article 8 of the Constitution of Ireland, the other official language being English. According to UNESCO (2019), the Irish language is classified as endangered due to a decline in intergenerational transmission and a decrease in the number of native speakers. Irish is primarily spoken as a community and home language in specific regions known as the *Gaeltacht*, located predominantly along the west coast of Ireland.

While Irish is the first language of Ireland, for a majority of children primary school is their first introduction to the language. Irish is taught as a compulsory subject from primary to Leaving Certificate level in the education system. In English-medium schools, Irish is taught as second language (L2) subject area to all students and is part of the core curriculum during the years of compulsory schooling 6-15. There is evidence suggesting a significant decline in Irish language proficiency in English-medium schools over the past few decades, as highlighted by the research of Harris, Forde, Archer, Nic Fhearaile, and O'Gorman (2006) and Harris (2008a). However, despite this decline, children generally maintain a positive attitude towards the Irish language, as indicated by the findings of Devitt, Condon, Dalton, O'Connell, and Ní Dhuinn (2018). In 2019, the Department of Education after extensive consultation with stakeholders (NCCA, 2018) launched a redeveloped Primary Language Curriculum (PLC), which promotes and encourages an integrated approach to the teaching and learning of languages. The curriculum incorporates transferable skills between English and Irish languages, a continuum of language learning for both languages, and diverse pedagogical approaches for language instruction (Government of Ireland, 2019). Notably, play is emphasised as an effective method for fostering integrated literacy skills (Government of Ireland, 2019, p. 46).

The use of technology and robotics has been used in classrooms for many years to support children's learning (Stork, 2020). In recent years in the Irish context there has been a more specific focus on coding and computational thinking skills and children’s use of digital devices (NCCA, 2019). This research intervention uses a floor programmable robot during a playful storytelling activity for second language learning. The children develop computational thinking skills as they use the robot for the storytelling activity. Computational thinking skills are applicable across many areas of the curriculum and provide a structure for problem solving. The National Council for Curriculum and Assessment (NCCA) has been at the forefront of the integration of computational thinking as a crucial skill in Irish primary schools. The NCCA highlighted the significance of computational reasoning as an essential capability for children in the digital age (NCCA, 2018). Children gain a deeper comprehension of the computational processes that underpin technology and develop skills for critical thinking when computational thinking is incorporated into the curriculum of primary schools.

The focus for this research intervention is on second language learning and how the use of robotics in a playful environment can support this process. This research project contributes a working hypothesis that the language learning process and aligns with the development of computational thinking skills under domain general processing. Emerging research in the field of literacy and digital tools indicates the parallels in the learning process between computational thinking and the writing workshop where meaning is abstracted from the task, a solution or written piece is created which aligns with algorithmic thinking and then edited which aligns with debugging (Hassenfeld, Z. R., & Bers, M. U. 2020).

1.2.2 Aims of the Study

The purpose of this study is to investigate the effect that a floor programmable robot can have on second language learning and computational thinking skills development when used during a playful storytelling activity.

The primary aims of this research were as follows:

- To explore the second language learning process through a sociocultural play-based intervention.
- To explore the impact of a play-based robotics-based intervention on children’s computational thinking skills

- To explore children's attitudes towards learning Irish during a playful storytelling activity, facilitated by a floor programmable robot
- To make a meaningful contribution to the wider policies and practices related to language learning in schools, particularly in the context of minority languages.

1. To explore the second language learning process through a sociocultural play-based intervention.

This study aims to examine the process of second language learning in a Junior Infant classroom through a play-based activity. The intervention involves storytelling and provides children with opportunities to engage in social interactions using their newly acquired language. While the study does not specifically address language acquisition, it focuses on understanding the language learning process and how a play-based intervention can facilitate this process.

2. To explore the impact of a play-based robotics-based intervention on children's computational thinking skills

The study seeks to investigate the role of a robotics-based activity in enhancing children's computational thinking skills. By incorporating a floor programmable robot, the study utilises a play-based storytelling approach to examine how children develop their computational thinking skills and how they collaboratively support one another as a group to foster these skills.

3. To explore children's attitudes towards learning Irish during a playful storytelling activity, facilitated by a floor programmable robot

The study seeks to explore children's attitudes towards learning Irish as a second language and what potential impact a robotics-based activity may have on their attitude towards learning Irish.

4. To make a meaningful contribution to the wider policies and practices related to language learning in schools, particularly in the context of minority languages.

This study seeks to contribute to the existing knowledge and practice concerning the learning and teaching of the Irish language in English-medium primary schools in Ireland, specifically focusing on the early years of primary school. Inspectorate reports

(Inspectorate 2022, 2018, 2013) and previous studies (Harris et al., 2006; Hickey & Stenson, 2016a) have expressed concerns regarding the learning and teaching of the Irish language in English-medium schools. In light of these concerns, this study aims to provide an alternative approach by developing a playful learning activity for the Irish language.

1.2.3 Research Questions

The research questions evolved from the context and aims for this study and are as follows:

1. What are children's attitudes towards using robotics for second language learning?
2. What evidence of language learning can be observed during a robotics-based intervention and what are the processes that support this learning?
3. What evidence of the development of computational thinking skills can be observed during a robotics intervention and what are the processes that support this learning?

1.3 Summary of thesis structure

There are nine chapters in this thesis. This current chapter aims to situate the context and motivation for the research and the significance of the study in the Irish early year's primary classroom.

The conceptual framework and relevant literature base for the study is examined in chapters 2 and 3. Chapter 2 presents the conceptual framework for this research of SCT and second language learning. Section 2.1 outlines language learning theories in particular ghighlighting second language learning and teaching and a developmental perspective on language learning. Section 2.2 looks at sociocultural theory and its constructs. This section also looks at the role of learning autonomy in the classroom. Section 2.3 reviews the literature on Irish in English-medium Primary Schools. This section includes a review of the curriculum, standards and attitudes in Irish language education and an integrated approach to language learning and teaching.
Chapter 3 explores the literature in relation to constructionism and situating CT skills in an early year’s curriculum. Section 3.5 looks specifically at coding as a literacy in the early years and the role programmable robotics plays in current research.

The methodological approach, procedures, and design process for the thesis are explored in chapters 4 and 5. Chapter 4 presents the design of this research. Section 4.1 outlines the research questions, which direct this study and the methodology of Design-Based Research (DBR), which was viewed as the most suitable approach for the study given the nature of an ever-changing classroom environment. This chapter also looks at the use of a mixed methods approach that was applied to the study. Section 4.7 and 4.8 describes the research instruments used for data collection and the data analysis process. Section 4.10 in this chapter reviews the ethical considerations for this study, including the child voice methodology. The final section, 4.11, reviews the limitations of this research study.

The design process is presented in chapter 5, setting out the iterative design cycle of this Design-Based Research study from conceptualisation, exploration of the activity design and pedagogy design decisions. This chapter reviews the three pilot cycles of the study and the testing and revision of each of the research instruments employed during each. The findings from the pilot cycles are outlined and discussed in section 5.3, with contributions from the pilot cycles concluding this chapter in section.

Chapters 6 and 7 present and discuss the findings from the main cycle of the research. The approach taken in cycle four is outlined in chapter 6, this includes; pedagogical considerations; technological considerations; school selection; and duration of the cycle. Data collection and analysis for this cycle are presented in section 6.4. Chapter 7 draws together the results of this research intervention. This chapter includes sections on SCT (section 7.2), language (section 7.3), CT skills (section 7.4) children's perspectives (section 7.5), and the teacher's perspectives (section 7.6).

Chapter 8 and 9 present the final part of this thesis; the discussion and conclusion. The discussion for the research is presented in chapter 8. Each research question is discussed in turn while drawing upon the results from chapter 7 and the literature review from chapter 2 and 3. Chapter 9 provides conclusion and recommendation from the research intervention, specifying the contributions to knowledge in section 9.2 along with specific recommendations for policy and practice in section 9.3 and setting out directions for future research in section 9.4.

2 Sociocultural Theory and Second Language Learning

Chapter One provided an introduction to the study, outlining the motivation for the study, the context, and the aims and research questions guiding the research. Additionally, a summary of each chapter is provided to place these key elements within the broader scope of the study.

This chapter is one of two literature review chapters and focuses on the theoretical framework of sociocultural theory that underpins the current study's approach. The chapter begins by discussing the rationale for selecting sociocultural theory as the most effective framework to inform the study's approach, specifically within the domain of language learning (Section 2.1). It then delves into a detailed exploration of sociocultural theory and its key constructs in Section 2.2, including mediation, the zone of proximal development, and scaffolding. Section 2.3 provides a historical overview of the Irish language in English-medium primary schools, with a particular emphasis on curriculum development and children's attitudes towards learning the language. This section contextualises the study within the broader landscape of Irish language education. The final section (Section 2.4) examines theoretical perspectives on second language learning. It explores principles of instructed language learning, content, and language integrated learning (CLIL), and translanguaging. These perspectives contribute to the understanding of second language learning and inform the study's approach to integrating language learning in a playful manner.

2.1 Language Learning Theories

This section provides a brief summary of theories related to (second) language acquisition. This study is focused on second language learning with a specific focus on oral language development through storytelling in a play-based activity. The language learning theories outlined in this section are considered in the context of the study and lay the groundwork for the selection of sociocultural theory as the theoretical framework for this research.

2.1.1 Second language learning and teaching

Over the past fifty years, the principles underlying second language learning and teaching have changed and developed. Larsen-Freeman (2011) outlines the development in the field commencing with the audio-lingual method, which is a behaviourist approach where learners sat as a passive imitator of the language they heard. At the same time, this method was initially seen as an advance in the grammar-translation method that had dominated language teaching until then (Lightbown, 2000).

Many researchers rejected the approach of the audio-lingual method and began to investigate other theories. Krashen (1985) one of the most notable theorists in the area, presented several hypotheses in relation to language acquisition. Krashen's input hypothesis outlined the necessity of comprehensible input in language acquisition (Krashen, 1985). Learners need to receive a huge amount of input if they are to learn a language. Larsen-Freeman (2011) recognised that input alone is not sufficient. He identified other factors such as the affective filter hypothesis, which can hinder learning. If the child is not motivated and they do not see the need to learn the language or are not developmentally ready for a particular feature of the language they are exposed to, then learning may not take place (Larsen-Freeman, 2011). The language input may be filtered out by the child (Lightbown & Spada, 2013). Swain (1985) developed the output hypothesis, which emphasised the role of comprehensible output in language acquisition. If language learners are to communicate, they must be able to make what they say comprehensible to others. This approach can help children focus on the form of the language they are using and give the teacher opportunities for feedback. The focus on input and output led to an investigation of the role of interaction. When children produce language output during interactions; with their teacher; other children; and native speakers, they are negotiating for meaning and have opportunities to receive feedback. According to Long’s (1996) interaction hypothesis this can lead to language acquisition.

Gass and Mackey state that effective second language learning takes place when the learner is exposed to; the target language; has an opportunity to produce the language and receives feedback on that production (2015). This is known as the interaction approach. The role of interaction is prominent in most current perspectives on SLA. Gass (2003) notes that interaction research "takes as its starting point the assumption that language learning is stimulated by communicative pressure and examines the relationship between communication and acquisition and the mechanisms (e.g., noticing, attention) that mediate between them" Gass (2003) (p.224). High-quality language input is important for the language learner. Input refers to the language that the learner is exposed to during the communicative context. This can range from reading, listening, or visual language (sign language). Interaction is a central ingredient in SCT.

A lot of research in SLL has focused on cognitive factors where the learner is seen to be hypothesising about language in one form or another. In more recent years research has examined the social factors that have an impact on SLL (Larsen-Freeman, 2011). The reason for this is that when we use a second language, we tend to use it in a social environment. This recent emphasis on social factors was influenced by Vygotsky (Ellis, Loewen, & Erlam, 2006). Supporters of the SCT approach to language learning tend to be critical of research that focuses on learning as a purely cognitive activity (Ó Duibhir & Cummins, 2012). From a sociocultural perspective, meaning or understanding is created during social interactions rather than in the minds of individuals alone. If we were to focus solely on the individual, the learning environment or the content being taught in a decontextualized way is to ignore "the ways in which learners exercise their agency informing and reforming their identities in those contexts" (Norton & Toohey, 2001, p. 318). Swain et al. (2011) suggests a more holistic perspective on learning where "identity is never determined by one person alone, but it socially constructed". Consideration must be given to the influence that societal factors also exert on identity formation in relation to language learning.

2.1.2 Developmental perspective to language learning

Traditionally in the field of language acquisition, there have been disagreements between what is described as the nativist and the empiricist language approach (MacWhinney, 1999). Whether language is an innate ability or biologically determined is realised and depends on the environmental input. A distinction between these two accounts is that, in a nativist tradition, language is seen as a particular cognitive capacity, which is a specific and a unique domain that is part of the human biological make-up, whereas empiricists view language acquisition as part of rather than separate from general cognitive abilities (Shiel, Cregan, McGough, & Archer, 2012). Shatz's (2007) comments on recent trends that "the literature is showing an increased appreciation of the multiple interacting factors which contribute to language acquisition and the ways in which the relative importance and contribution factors may vary with development". The nature versus nurture argument is decreasing with the development of a more refined understanding of the interaction between genetic inheritance, neurological development, and the moderating and mediating effects of the environment (Warren & Abbeduto, 2007).

The emergentist theory draws upon both the nativist and the empiricist theory to give a complete picture of what second language acquisition looks like (MacWhinney, 1999). The emergentist perspective views that as a child's language develops, their physiological, cognitive, and social development also develops. These four aspects of a child's development have an impact on each other. The position of the emergentist seeks to explain language acquisition in terms of the interaction between the children's learning mechanisms and the environmental input (Hoff, 2004). There is an agreement between what is encoded biologically and the importance of innate knowledge (Hoff, 2004). Shiel et al. (2012) outline that "the fundamental concern is with the ways in which linguistics and cognitive structures emerge" as children are learning and developing and how the quality of collaborative mediation can affect cognition.

The emergentist position is compatible with second language acquisition from a developmental perspective. Bilingual children can be divided into two categories: the child who is simultaneous bilingual and who learns both their languages in the pre-school years, and; the child who becomes proficient in their first language, which they speak at home, and who learns their second language at school (Paradis, 2007; Paradis et al., 2011). The latter applies to this study. A majority of children in Irish schools learn Irish as their second language, and for some, it may be their third or fourth language. Cummin's hypothesis on the interdependence of first and second language and the “common underlying proficiency model” (Cummins, 1979, 1991, 2000) aligns with a developmental perspective on second language acquisition. This is that the first language skills support SLL because the underlying proficiencies in linguistic-conceptual knowledge are in play and the first language acquired provides a base for the second one (Hammer, Scarpino, & Davison, 2011). These are also known as transferable skills, which are highlighted in the PLC (2019).

The process of language learning, as it progresses towards proficiency in a target language, aligns with the emergentist perspective that acknowledges the influence of physiological, cognitive, and social development on language acquisition. Shiel et al. (2012) argue for a developmental perspective that recognises children's growth in knowledge, comprehension, and utilisation of both their first and second languages as a continuum, allowing for individual variations in learning profiles.

2.1.3 Exploring Language Learning Theories

The current study adopts Sociocultural Theory (SCT) as the foundational framework for investigating second language learning in the context of a play-based robotics intervention. This intervention entails children actively participating in storytelling activities using the target language while employing the robot as a mediator to facilitate their learning process.

In addition to SCT, two alternative theories, namely the interactionist approach and complexity theory, were taken into account during the study's theoretical considerations. The interactionist approach emphasises the significance of social interaction in language learning, positing that learners' communicative abilities are cultivated through their interactions with peers and more knowledgeable individuals. Complexity theory, on the other hand, highlights the intricate nature of second language acquisition, acknowledging that language learning is a dynamic and non-linear process influenced by various interconnected factors.

By selecting SCT as the primary theoretical framework, the study underscores the importance of social and cultural aspects in the language learning process, as well as the potential of a play-based robotics intervention to enhance language acquisition in children. This choice is reinforced by acknowledging the interactionist approach, which aligns with the collaborative and communicative nature of the storytelling activities in the intervention. Moreover, considering complexity theory bolsters the understanding that language learning is a complex and multifaceted phenomenon, and the play-based approach with the robot as a mediator allows for the exploration of these intricate dynamics in a real-world educational setting.

Through the integration of SCT and the acknowledgment of alternative theories, the study aims to provide a comprehensive and robust framework for analysing the effectiveness of play-based robotics interventions in promoting second language learning among children. By doing so, this research contributes to the existing body of knowledge on language acquisition and pedagogical strategies, with potential implications for educational practices and curriculum development.

The next section will offer concise overviews of each of the aforementioned theories: Sociocultural Theory (SCT), the interactionist approach, and complexity theory. These summaries will enable a better understanding of the theoretical foundations underpinning the study's investigation into second language learning within a play-based robotics intervention.

2.1.3.1 Interactionist Approach

The Interaction Hypothesis, initially developed by Long (1980, 1981, 1983), has been expanded upon by various researchers such as Gass and Varonis (1985, 1994), Mackey (1999, 2006), Pica (1987, 1988, 1994), and Pica, Young, and Doughty (1987). Long's work was influenced by Wagner-Gough and Hatch (1975) and Krashen (1985), who emphasised the role of conversation in language learning. Wagner-Gough and Hatch (1975) proposed that conversation is not just a means to practice language, but a central aspect of learning itself. Long's theory aligned initially with Krashen's Input Hypothesis, which suggests that input slightly above a learner's current level can facilitate language development. However, Long expanded his theory to incorporate conversational adaptations that make input more comprehensible and supportive of second language (L2) development (Kim, 2017).

Interactionism is an established approach to language learning, supported by researchers such as Gass and Mackey (2007), Gass, Abbuhl, and Mackey (2013), Kim (2017), and Atkinson (2014). Mackey's study (1999) provided comprehensive evidence for the effects of an interactionist approach, particularly highlighting the significance of structure-focused exchanges in promoting L2 development (Gass, 2002). Gass and Varonis (1994) demonstrated a direct relationship between interaction and learners' linguistic production, emphasising the role of negotiation of meaning in L2 production (Kim, 2017).

The understanding of the interactionist approach has evolved to incorporate additional factors such as corrective feedback, implicit and explicit learning, and the importance of output (Gass & Mackey, 2020). This expanded perspective recognises the complex interplay of interaction, feedback, and different learning processes in language acquisition.

2.1.3.2 Complexity Theory

Complexity Theory was initially introduced to the field of language acquisition through a study conducted by Larsen Freeman in 1994. As a result, it is regarded as a relatively recent theoretical framework within the language acquisition context (Hiver, Al-Hoorie, & Evans, 2022).In complexity theory, language learning is viewed as a complex system that involves the interaction of various elements, such as learners, their social and physical environment, and the linguistic input they encounter (Larsen-Freeman, 2017; Larsen-Freeman & Cameron, 2008). The learning process is not seen as a linear progression, but rather as a complex, non-linear phenomenon with multiple possible outcomes. By adopting a complexity theory perspective, language educators can approach language teaching and learning as a dynamic and unpredictable process. They can create learning environments that encourage exploration, interaction, and engagement, allowing learners to actively participate in the co-construction of their linguistic knowledge (Larsen-Freeman, 2017; de Bot et al., 2007). This learner-centred approach promotes adaptability, autonomy, and a focus on meaning-making rather than rigid rule-based instruction (Larsen-Freeman & Cameron, 2008; Larsen-Freeman, 2006).

Complexity theory has been widely applied in second language acquisition research, providing insights into the dynamic nature of language learning processes (Ellis, 2015). It offers a holistic perspective that goes beyond the traditional focus on discrete language elements and considers the complex interactions and emergent properties of the language system (Larsen-Freeman, 2006). This theoretical framework has contributed to a deeper understanding of language development, language variation, and the role of social interactions in language learning.

2.1.3.3 Sociocultural Theory

The foundations of sociocultural theory (SCT) can be traced back to the pioneering work of Vygotsky (1978), whose research and writings laid the groundwork for this theoretical perspective. SCT posits that human mental functioning is fundamentally a mediated process that occurs through the use of cultural artifacts, activities, and ideas (Ratner, 2002). Within the framework of SCT, individuals utilise the tools and resources available in their sociocultural environment to regulate and enhance their cognitive processes.

SCT highlights the importance of the social context in shaping language learning and development. Language is viewed as a cultural tool that plays a central role in mediating cognitive processes (Lantolf & Thorne, 2006). Vygotsky emphasised the significance of language as a means of communication and as a tool for thought (Vygotsky, 1986). Language allows individuals to express their thoughts, negotiate meaning, and interact with others, thereby facilitating their cognitive growth and development.

The application of SCT in the field of language learning has gained traction since the 1980s, as researchers recognised the need to consider the learners' social context and the language learning environment (Breen, 1985). This shift in perspective reflected a dissatisfaction with earlier approaches that focused solely on internal cognitive processes. SCT provided a valuable framework for investigating the interplay between individual learners, their sociocultural contexts, and the cultural artifacts that mediate their language learning experiences.

The sociocultural perspective on language learning has influenced numerous studies and has shaped our understanding of how social interactions, cultural factors, and historical artifacts contribute to language development (Lantolf & Thorne, 2006; Thorne & Reinhardt, 2008). Researchers have explored the role of collaborative dialogue, scaffolding, and the zone of proximal development in language learning within the SCT framework (Swain & Lapkin, 2001; Ohta, 2001). This theoretical perspective has highlighted the inseparable relationship between language, culture, and cognition in the process of language learning and has provided valuable insights into the dynamic nature of language acquisition.

2.2 Sociocultural Theory

This section delves into the origins of Social Cognitive Theory (SCT) and its fundamental constructs, which are essential components upon which the theory is built (VanPatten & Williams, 2015). The primary construct of SCT is mediation (section 2.2.2). It is closely intertwined with regulation (2.2.2.1) and internalisation (2.2.2.2). Additionally, SCT encompasses other constructs such as private speech and the zone of proximal development (ZPD) (2.2.5).

The reason for selecting SCT for this study lies in its comprehensive approach to learning. It not only considers a child's cognitive development but also takes into account their development within their environment, acknowledging the continuous progression throughout their time in school. The study is conducted in an early years' classroom, where children are utilising an "artifact" - a programmable floor robot - to facilitate their second language learning and communication. Throughout this process, the teacher continuously scaffolds, observes, assesses, and reflects on the children's development. A crucial element of SCT is scaffolding, which explores how children can support each other as they become more familiar with the activity. The mediation process involves using objects in their environment, such as the robot and the floor mat on which the robot moves.

The following section will provide an in-depth examination of each of the SCT constructs concerning language development and skill development. These constructs include Mediation, Regulation, Internalisation, Zone of Proximal Development, and Scaffolding.

2.2.1 SCT

Sociocultural theory (SCT) is based on the notion that the human mind is mediated by the tools and social environment surrounding an individual (Gass & Selinker, 2008). It emphasises the interconnectedness of mental processes and the social context, rather than viewing them as separate entities (Ní Aogáin, 2019). According to this perspective, language learning occurs not only within the learner's mind but also through interactions with others and the collaborative construction of meaning (Ellis & Shintani, 2013). When children collaborate to solve challenging tasks, they engage in negotiation and develop shared understandings, which are subsequently internalised and drawn upon in similar situations (Swain & Deters, 2007). Sociocultural theorists argue that a child's social and cultural environment, such as their school or home, plays a crucial role in their cognitive development. Language, in this context, is not merely a means of expressing ideas, but a tool that mediates the mind and facilitates collaborative processes (Thorne & Tasker, 2011).

Sociocultural theory provides a common understanding on language learning and development, as it considers the influence of attitudes, cultural factors, and social factors on children's learning and development (Lantolf & Poehner, 2014). It also highlights the variability of learning experiences within different settings. SCT researchers argue that contextual experiences can have diverse effects on a child's learning, leading to different outcomes (Lantolf & Poehner, 2014).

In 1978, Vygotsky proposed a framework of development that encompasses two interconnected levels. The first level involves social interaction, while the second level pertains to cognitive or mental comprehension. . Vygotsky called these two levels the inter-psychological plane and the intra-psychological plane (Vygotsky, 1978). Aligning with Vygotsky, Aljaafreh and Lantolf (1994), Swain, Kinnear, and Steinman (2011), Lantolf, Thorne, and Poehner (2015), Thorne and Tasker (2011) outline that language learning or language development happens initially as children interact with each other and objects in their social environment within the inter-psychological plane, and that learning is internalised on the intra-psychological plane. According to Vygotsky, children progress and transition from one level of development to another through interactions that are mediated by a more knowledgeable other (MKO) in their environment. This MKO can take various forms, including teachers, peers, or cultural tools that facilitate learning (Lantolf, 2000). Through these mediated interactions, the MKO creates opportunities for the child's development on an inter-psychological level, which may not have been possible through individual efforts alone.

A wide range of tools and resources available in the child's environment also play a crucial role in supporting their development. These can include physical objects such as building blocks, sand pits, pencils, papers, crayons, as well as technological devices. Language itself is considered one of the essential tools in this collection that aids a child's progression from one developmental plane to another (Vygotsky, 1978). By interacting with the MKO and utilising the available tools and resources, children engage in a socio-culturally situated learning process. They internalise the knowledge and skills acquired through these interactions, which ultimately leads to their individual cognitive development (Vygotsky, 1978). The concept of mediation and the use of tools within the sociocultural perspective emphasise the collaborative and interactive nature of learning, highlighting the important role of social interactions and cultural artifacts in shaping children's cognitive growth and language development.

2.2.2 Mediation

A review of SCT constructs must begin with the most fundamental construct, mediation. Mediation is the core construct of SCT that brings all other SCT constructs together. The basis of this construct is that children do not act directly on the world but that their mental and physical activities are mediated by symbolic artifacts such as language, literacy, numeracy, as well as by material artifacts and technologies (Lantolf et al., 2015). Instead of a traditional perspective on the workings of the mind, Vygotsky posits that humans do not act directly on the physical world, but instead they rely on tools to change their world and their environment and therefore their situations. These tools act as "a buffer between the person and the environment" and they "mediate the relationship between the individual and the social-material world" (Lantolf et al., 2015, p. 3). These tools in our environment can also be used to mediate our relationships with others, with ourselves and so change the nature of these relationships (Lantolf, 2000). Mediation refers to the use of tools as aids or supports in achieving something that was previously too difficult for a child to achieve by themselves (Aimin, 2013, p. 166).

Mediation in second language learning (SLL) can be categorised into three distinct forms: mediation by artifacts or objects, mediation by private speech, and mediation by others through social interactions with more knowledgeable individuals such as teachers or peers (Ellis, 2015). Vygotsky (1978) underscores the significance of language as the most powerful psychological tool that enables humans to mediate their behaviour within their social environment and in their inner thoughts. Language empowers individuals to transcend their immediate surroundings, allowing them to think about and discuss events and objects that are physically and temporally distant (Gass & Selinker, 2008, p. 284). In the context of second language learning, mediation offers a valuable lens for assessing children's L2 development. Mediated tasks provide insights into a child's ongoing interlanguage development as they rely on various forms of mediation to convey meaning (Lantolf & Poehner, 2011).

Sociocultural perspectives rationalise that language development occurs as a child becomes less dependent on mediation forms, such as the classroom teacher or scaffolds, and gains the ability to perform tasks independently (Lantolf, 2006; Lantolf & Thorne, 2006). Ellis (2000) emphasises that successful L2 development is achieved through mediated interactions that involve an appropriate level of assisted learning tailored to the child's learning journey.

According to Lantolf and Poehner (2014, p. 173), appropriate mediation in language learning varies across three planes: individual factors, timing, and features of the second language. These factors influence the level of mediation or scaffolding required to guide the child toward Vygotsky's Zone of Proximal Development (ZPD). The ZPD, a central concept in sociocultural theory, highlights how collaborative mediation, provided by a more knowledgeable other (MKO), enables a child to accomplish tasks beyond their independent capabilities (Lantolf, 2011).

As previously mentioned, Vygotsky argued that humans have the ability or capacity to use symbols as tools to mediate their mental thoughts. Physical tools are used outwardly, such as a pencil for writing, and symbolic tools are used inwardly, such as our mental thoughts. Physical tools have the ability to enhance the physical world, while symbolic tools are used to “reorganise our biologically endowed psychological processes” (Lantolf et al., 2015). As humans, we have the ability to control this output and delay it. While we know we will use a crayon to draw a picture; we might first consider what we might include in the picture and the setting. This indicates that we can control our output or activity and delay an automatic response, unlike other species. Rather than reacting, we have the ability to reflect, consider possible actions and plan. We plan on an “ideal plane and before realising them on the objective plane” (Lantolf et al., 2015, p. 5). This development is recognised in children, as they grow, moving from the reactionary output of crying when they are hungry to using speech to convey their hunger as they grow. A child might want a sweet. The child must consider whom they should ask for the treat and how they should behave to ensure they get the treat. This thought process takes place on the ideal plane. When the action is carried out it is taking place in the objective plane (Vygotsky, 1978). The planning that takes place in the child’s mind, such as who to ask and how requires planning. Planning indicates memory from a previous event or memory when they were also looking for a treat. They might consider what worked to achieve their objective and what did not. This, according to Vygotsky (1978), is human consciousness. As the child develops additional supports to mediate their thoughts, they are able to assess their situation and consider different strategies and various results on the ‘ideal plane’ before they carry it out on the concrete ‘objective plane’ (Arievitch & van der Veer, 2004). The child is essentially imagining what would happen in all the different scenarios in their mind before trying it out in real life. Mediation with tools is relevant to this investigation as the children use a programmable floor robot on the objective plane. Their planning of a route for the robot takes place on the ideal plane prior to executing it on the objective plane.

2.2.2.1 Regulation

Sociocultural Theory (SCT) places a significant emphasis on the concept of regulation, which is closely related to mediation. According to Lantolf et al. (2015), when children learn a new language, words not only serve the purpose of labelling objects and actions but also reshape their perception into cultural perception and concepts. As children engage in learning activities, they gradually develop the ability to regulate their own behaviour through language. This regulation occurs in three stages: object-regulation, other-regulation, and self-regulation.

- Object-regulation involves using objects in the environment to support thinking and cognition.
- Other-regulation refers to mediation by others through social interaction.
- Self-regulation occurs through the use of psychological tools, higher-order thinking processes, and private speech (Ellis, 2015).

Private speech refers to an individual's externalisation of language to maintain or regain self-regulation, focusing attention, problem-solving, supporting memory-related tasks, and making information salient to oneself (Lantolf et al., 2015). As children reach the self-regulated stage, they no longer rely on external objects or others' guidance. Instead, they utilise their internal resources to complete tasks and internalise their learning.

It is important to note that the stages of regulation—object-regulation, other-regulation, and self-regulation—are dynamic and fluid. Children may move back and forth across these stages depending on the task's difficulty level, a phenomenon known as "backsliding" (Lantolf & Thorne, 2006). Furthermore, high-quality teaching involves recognising the child's developmental continuum and providing appropriate support and repetition of earlier activities (Gallimore & Tharp, 1990).

2.2.2.2 Internalisation

Vygotsky proposed that internalisation involved the conversion of social relations into mental functions. It is the process of developing the ability to perform complex cognitive tasks with decreasing reliance on external mediation. Internalisation occurs when activities within the child's Zone of Proximal Development (ZPD) transition from the social realm to their cognitive functioning. This transformation of cultural artifacts, including language, from the social to the cognitive sphere is known as internalisation. It is a negotiated process that reorganises the child's relationship with their social environment and is reflected in their output. Internalisation is the mechanism through which individuals gain control over their thoughts and is integral to SCT.

Vygotsky's general law of genetic development states that every psychological function appears first between individuals on the interpsychological plane and then within the individual on the intrapsychological plane. Vygotsky suggests that the ability to imitate other people's intentional behaviour is key to internalisation. Imitation in this context is not a mere replication of acts but involves goal-directed behaviour. Collaboration and imitation-based development are fundamental to the emergence of specific human features of consciousness in children.

Imitation has been found to play an important role in language learning, according to child language researchers. It is not a simple copy of others' speech but a self-initiated behaviour by the child. Imitation is linked to internalisation and can occur after a delay, allowing the child to analyse language over an extended period. This delayed imitation serves as a foundation for spontaneous language use, forming a continuum between imitation and independent language production. Imitation of language can be likened to flexing the linguistic muscles to explore its effects and generate reactions.

2.2.3 Zone of Proximal Development

In the previous section (2.2.1), the concept of the zone of proximal development (ZPD) was discussed, as proposed by Vygotsky. Within this framework, Vygotsky identifies two levels of development in a child's learning journey. The first level represents the child's actual development stage, which can be understood by looking at their past accomplishments and acquired skills. The second level pertains to the child's potential development, signifying their future capabilities and learning potential (Vygotsky, 1978, p. 86).

The ZPD, as developed by Vygotsky, refers to the space that exists between these two levels of development. This zone can be narrowed and bridged as a child's learning capacities progress, especially if appropriate mediational tools and guidance are made available. In essence, the ZPD encompasses the "distance between the child's actual developmental level, determined by their ability to solve problems independently, and their level of potential development, which is ascertained through adult guidance or collaboration with more capable peers" (Vygotsky, 1978, p. 86). The key to fostering learning and development lies in understanding and leveraging this zone of proximal development, as it provides valuable insights into a child's potential for growth and learning with appropriate support and scaffolding.

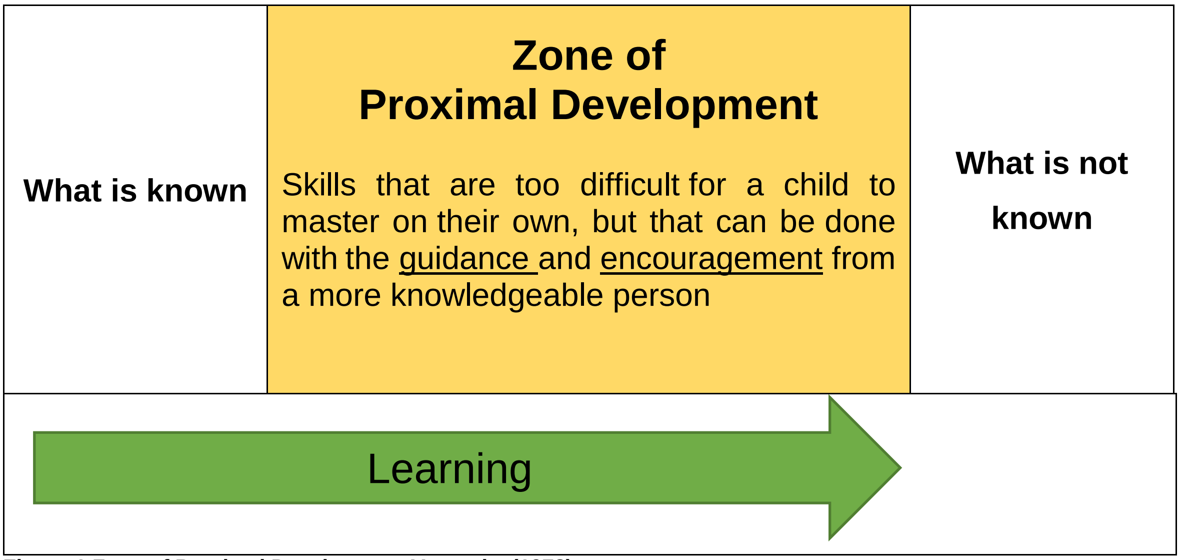


Figure 1 Zone of Proximal Development Vygotsky (1978)

The ZPD, a central idea in Vygotsky's theory, emphasises the significance of a child's past and future development opportunities with appropriate mediation support. Vygotsky describes the ZPD as a space containing functions that are in the process of maturation, not yet fully developed but capable of maturing in the future (Vygotsky, 1978, p. 86). The role of the human mediator, often referred to as the More Knowledgeable Other (MKO), is crucial in assisting a child's development between their current and potential levels. Collaborative mediation between the MKO and the child results in the co-construction of the metaphorical ZPD. This collaboration enables the MKO to recognise the child's emerging skills, facilitating the creation of an optimal learning environment. The role of the MKO is not limited to the teacher. A study conducted by Farndale, Harris, & de Courcy (2016) with children between 4-5 years old, observed the significance of the MKO partnerships among pre-schoolers, particularly those learning English as an Additional Language (EAL). Several instances were noted by the researchers where partnerships had a strong influence. For instance, an EAL student formed a close bond with two native English speakers, who helped improve their English communication. The MKO partnerships, characterized by expert-novice dynamics, provided valuable English language models for the focus children, aiding their EAL development (Farndale, Harris, & de Courcy, 2016).

Vygotsky posits that effective instruction within the child's ZPD involves activities that the child cannot perform independently but can accomplish through collaboration with others (Rassaei, 2017). Thus, effective teaching approaches should focus on the child's potential capabilities residing in the co-constructed ZPD, activating their higher-order functions (Lantolf, 2011).

The Vygotskian concept of the ZPD is frequently utilised by researchers in the field of second language learning (SLL) to conceptualise the SLL process and overall L2 development (Lantolf et al., 2015). Aljaafreh and Lantolf (1994) identify three critical mechanisms for effective intervention within the ZPD to enhance SLL. Firstly, as a child's ZPD is dynamic, the progression of the ZPD should be gradual, based on the developing linguistic capacities of the child. Support is recommended to be provided initially through implicit and general strategies to assess the child's abilities fully and then progressing to more specific strategies until the appropriate level of guidance needed by the child is achieved. Secondly, the child should receive support according to their specific needs (i.e., forms of placement support). It is emphasised that any form of mediation offered should decrease slightly as the child gains competencies in the desired language skills. Thirdly, the authors highlight the crucial significance of maintaining a dialogical ZPD that is co-constructed through mediated interactions between the child and the MKO. Aljaafreh and Lantolf (1994, p. 468) stress that "… without dialogic negotiation, it is virtually impossible to discover the novice's ZPD." The concept of ZPD acknowledges the importance of collaborative mediation in shaping the learning process (Gass & Selinker, 2008). Research indicates that utilising these three mechanisms can foster consistent growth and development over time, which is vital for a child's language development journey (Aljaafreh & Lantolf, 1994).

It is important to note that over or under assisting a child may hinder their capacity to progress through their ZPD (Lantolf et al., 2015). Therefore, establishing and maintaining an appropriate ZPD requires continuous assessment and reflection of the child's emerging capacities. The ZPD is dynamic and needs an open-ended perspective from both the MKO and the learner, which develops through mediated interaction, supporting language learning and subsequent language development (Aljaafreh & Lantolf, 1994; Swain, 2000). Holzman (2016) affirms this concept by suggesting that the ZPD is more easily understood as "an activity rather than an actual zone, space, or distance" (Holzman, 2016, p. 29).

Considering the ZPD as a "connecting" concept interlinking other constructs of Vygotsky's theory (section 2.2.), Tudge (1992) emphasises the importance of seeing the connections between the ZPD and the theory as a whole to differentiate Vygotsky's theory from other forms of aided instruction. To synthesise the concepts of Vygotsky's theory, Gallimore and Tharp (1990) propose a conceptual framework that integrates the elements of sociocultural theory (SCT) to explain a child's development through the ZPD. Gallimore and Tharp (1990) (Page 184-186) expand upon Vygotsky's two-staged concept of development and further propose a four-stage model of transition from the inter-psychological plane (i.e., other regulation) to the intra-psychological plane (i.e., self-regulation).

The ZPD is a crucial concept in Vygotsky's theory, emphasising the role of mediation support in a child's development. By considering the ZPD as a connecting concept, researchers can better understand the interrelated elements of Vygotsky's theory and its implications for language learning and development. The mechanisms of effective intervention within the ZPD offer valuable insights for supporting second language learning, and maintaining an appropriate ZPD requires continuous assessment and collaboration between the MKO and the learner. In the first stage, Gallimore and Tharp (1990) suggest providing directions and modelling to help the child learn. In the second stage, the child becomes more self-regulated in their learning process. At stage three, the child can achieve tasks independently, which were previously challenging without external help. In stage four, some functions may de-automatize, causing temporary regression. However, the ultimate goal is to return to assisted performance within the child's zone of proximal development to regain self-regulation and automatization.

2.2.4 Scaffolding

Facilitating a child through their Zone of Proximal Development (ZPD) involves providing suitable support to guide their learning and development (Ellis & Shintani, 2014). Scaffolding, originally coined by Wood, Bruner, and Ross (1976), is closely related to Vygotsky's theory of child development. Bruner (1983) defines scaffolding as a process of setting up the learning situation to make it easier for the child to enter successfully, gradually withdrawing support as the child becomes more skilled in managing the task. Scaffolding ensures that the learner's potential is reached, and the provided support should slightly surpass the child's current ability, aligning with their developing functions rather than their fully developed ones (i.e., their ZPD) (Vygotsky, 1978).

The definition of scaffolding has seen some variation, and researchers have struggled to reach a consensus on specific pedagogies and practices that constitute scaffolding (van de Pol et al., 2010; van de Pol, Volman, Oort, & Beishuizen, 2015). However, the concepts of contingency, fading, and the transfer of responsibility remain consistent among various scaffolding definitions (van de Pol et al., 2010). To understand the co-

construction of scaffolding between a child and a teacher (the More Knowledgeable Other or MKO in Vygotskian terms), van de Pol et al. (2010) present a conceptual framework. According to this model, the scaffold provided should be aligned with the child's ZPD, gradually adapting to their emerging capacities and operating slightly beyond their current ability. A crucial aspect is the initial assessment of the child's current and potential ability for scaffolding to succeed. As the child's developmental capacity grows, the scaffold must be gradually withdrawn as the MKO transfers responsibility to the child, allowing them to gain more control over higher-order functions (Vygotsky, 1978). This concept aligns with Aljaafreh and Lantolf's (1994) three mechanisms of effective intervention with the ZPD, emphasizing gradual reduction of mediation during language development.

Van Lier (1996) emphasises the significant role of the MKO and scaffolding in overall second language (L2) development. He argues that interactions among children with different cognitive abilities may enhance second language learning by encouraging diverse contingencies and discourse management strategies. Donato (1994) also supports the idea of scaffolding within a social and cultural context, suggesting that children working together on learning tasks can promote linguistic development, highlighting the importance of considering learners as sources of knowledge in a social context.

Peers within the sociocultural framework can act as MKOs, contributing to dynamic scaffolding relationships within a community of language learners. Swain's output hypothesis (2005) and the concept of collaborative dialogue or "Languaging" (Swain, 2006) further support the notion of peer scaffolding. Within this framework, children engage in dialogue to resolve linguistic problems, building on each other's knowledge through language as a mediational tool (Swain & Lapkin, 2001). Gallimore and Tharp (1990) emphasise the value of scaffolding within the social environment, as assistance is necessary until internalisation of knowledge occurs, particularly in L2 instruction when new tasks are introduced to children.

While Vygotsky (1978) primarily addresses overall child development, the sociocultural theory (SCT) has been applied to understand and evaluate L2 development by researchers such as Lantolf (2000) and Swain (2006). The SCT views the social arena as a source of mental development, and within a school environment, specific cultural tools can mediate the learning process. Indications of L2 development can be observed when children rely less on external tools to mediate their thinking and learning (Lantolf et al., 2015).

2.2.5 Learner autonomy

The prominence of learner-centred approaches in language learning has prompted researchers to explore the role of learner autonomy, defined by Little (1991, p. 4) as "a capacity – for detachment, critical reflection, decision-making, and independent action." Section 2.2.3 of the study highlights that learner autonomy can be situated within the child's Zone of Proximal Development (ZPD) as posited by Gallimore and Tharp (1990). Sociocultural Theory (SCT) serves as the theoretical lens through which learner autonomy is examined. Little (2007, p. 23) proposes three interacting principles essential for successful second language teaching: learner involvement, learner reflection, and target language use. Consequently, the teacher plays a pivotal role in enabling learners to gradually develop autonomy, taking ownership of their learning process. With the advent of digital technologies in educational settings, language learning and teaching undergo a re-evaluation, affording greater opportunities for autonomous learning and skill development. Rather than mere imitators, children are viewed as language creators and innovators, embarking on a transformative learning journey (Ó Duibhir & Cummins, 2012).

The concept of autonomy in the classroom can be linked to Self-determination Theory (SDT). When applied to the learning environment, SDT emphasises promoting children's interests in learning, fostering a sense of importance in learning, and instilling confidence in their learning abilities (Deci and Ryan, 1985, 1991). SDT posits that individuals possess inherent tendencies toward psychological growth and integration, leading to a natural inclination for learning, mastery, and connection with others (Ryan & Deci, 2020). Fulfilment of these needs requires appropriate support or scaffolding. SDT identifies three fundamental needs crucial for development: autonomy, competence, and relatedness. Autonomy, as described by Ryan and Deci (2020), “involves a sense of initiative and ownership in one's actions”.

The integration of SCT and SDT within the context of the study's play-based robotics intervention could potentially highlight the significance of learner autonomy in second language learning. By fostering a supportive environment that caters to learners' autonomy, competence, and relatedness, educators could enhance the effectiveness of language teaching practices. Moreover, acknowledging the role of digital technologies in this process emphasises the evolving nature of language learning and the imperative to adapt pedagogical approaches to accommodate learners' changing needs and capabilities. This combination of theoretical perspectives contributes to a comprehensive framework for promoting language acquisition and autonomous learning in children, underscoring its potential implications for educational advancements.

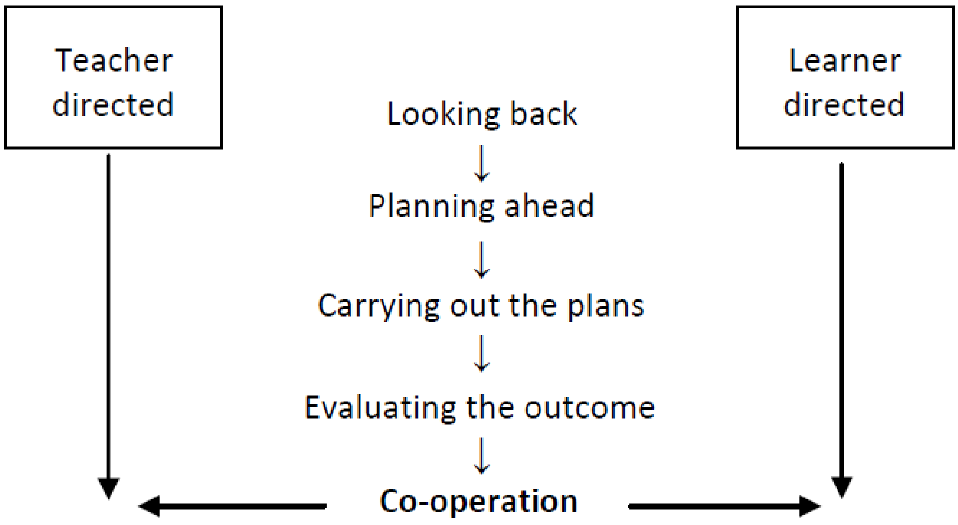


Figure 2 Developing learner autonomy - a simplified model Dam (2011, pg. 41)

In the context of discussions surrounding learner autonomy, Dam (2011) makes an interesting observation regarding the role of the teacher in the classroom. Despite learner autonomy often being misconstrued among teachers and parents, it is not synonymous with a hands-off approach in the learning environment. The notion of learners becoming fully autonomous from the outset of encountering new subjects or disciplines is misguided (Dam, 2011). In many cases, the teacher's guidance is indispensable to lay the groundwork for effective learning. Only after a solid foundation is established does the learning process transition into a collaborative endeavour, with both the teacher and the learner working in tandem.

This perspective aligns with the findings of Little (1991), who emphasised that learner autonomy is a gradual development. Little defines learner autonomy as "a capacity – for detachment, critical reflection, decision-making, and independent action" (p. 4). Little's insights also highlight that learners cannot be expected to achieve autonomy on the first day of encountering new content; instead, they require support and scaffolding from the teacher to build autonomy gradually.

Furthermore, Benson (2001) argues that learner autonomy involves a sense of control and ownership over one's learning process. Learners become more autonomous when they are actively engaged in setting their goals, selecting appropriate learning strategies, and evaluating their progress. This aligns with Dam's (2011) observation that in the collaborative phase of autonomy, learners reflect on their needs while the teacher provides guidance and support to move the learning process forward.

The role of the teacher as a facilitator of learner autonomy is further supported by Holec (1981), who suggests that teachers should create a supportive environment that encourages learners to take responsibility for their learning. This entails fostering a culture of reflection and metacognition, where learners can critically assess their strengths and weaknesses and make informed decisions to enhance their learning experiences.

By acknowledging the interplay between teacher guidance and learner autonomy, educators can strike a balance between structured instruction and student-centred learning, as advocated by Dam (2011). This approach empowers learners to take ownership of their learning journey while benefiting from the expertise and scaffolding provided by the teacher, as highlighted by Benson (2001, 2007). Ultimately, such a balanced approach can lead to more meaningful and sustainable learning outcomes, equipping learners with the skills and metacognitive strategies necessary to become lifelong autonomous learners (Dam, 2011; Little, 1991).

2.3 Irish in English-medium Primary Schools

This section provides a concise historical overview of the development of the Irish language curriculum as a fundamental subject in the Irish education system. Since 1922, the Irish language has been designated as a core subject in primary education. Over the years, the primary language curriculum has undergone several revisions in 1971, 1999, and most recently in 2019. Each revision has aimed to incorporate updated language learning and teaching practices based on international research findings. Section 2.3.2 examines current societal attitudes towards Irish; children's attitudes and motivation towards learning Irish as a second language in English-Medium schools, while Section 2.3.3 explores the current Primary Language Curriculum and its integrated approach to language learning.

2.3.1 The Irish language curriculum

Since 1922, the Irish language has been an integral part of the primary school curriculum, encompassing three core strands; oral language, reading, and writing, which children begin to experience from their first year of school. In 1971, a significant revision of the primary curriculum took place, coinciding with the 50th anniversary of the national education system's establishment (Dunne, 2019). This revision was influenced by evolving understandings of childhood and its crucial role in human development, as well as the changing perception of schools in children's lives. Schools were no longer seen as the final destination in a child's learning journey (DES, 1971, p. 15). The 1971 curriculum incorporated important learning principles, including the promotion of group work and differentiation.

During the 1970s, an innovative language teaching approach known as the audio-visual method emerged, aligning with international practices (Section 2.1.1). The language curriculum was shaped by theories of cognitive psychology, which emphasised the significance of exposing learners to rich language input (Section 2.1.3). Harris and Murtagh (1999) highlighted the strengths of Irish language instruction during this period, viewing it as teaching a second language rather than a "foreign" or modern language. This distinction was due to the prevalent use of Irish throughout the lessons and its application beyond dedicated Irish language classes.

The language curricula for Irish and English were presented in their respective languages, assuming that teachers had the necessary proficiency to access and understand the content in Irish. However, one of the challenges encountered during the implementation of the language curriculum was the heavy reliance on whole group instruction, particularly concerning the development of oral language skills. This approach significantly limited opportunities for natural conversations and peer interactions to take place, as pointed out in the 1971 Department of Education and Science (DES) report (p. 76).

Almost thirty years later, a revised version of the primary school curriculum was introduced in 1999, receiving commendation for its holistic and child-centred approach. The curriculum emphasised the importance of emotional expression and acknowledged the abilities of all children, as highlighted by Downes (2003). Notably, this revision marked a shift in how the curriculum was made available to teachers. Each subject, including language instruction, had its own separate hardcopy document, color-coded by area, along with accompanying teacher guidelines and curriculum content documents.

In terms of language curricula in Ireland, there was no separate document specifically designed for Irish-medium and English-medium schools. However, there were acknowledged differences between schools where Irish was the primary language (Teanga 1) (Dunne, 2020). Despite this, the curriculum objectives remained the same for both language curricula, regardless of the language of the school. There was also no further distinction made between schools in the Gaeltacht (Irish-speaking regions) and Irish-medium schools located outside the Gaeltacht.

In the development of the language curricula, a communicative approach to language teaching (CLT) was adopted as the primary method. This decision came after trial runs of communicative materials and collecting feedback from various sources, as outlined in the work of Harris and Murtagh (1999). The Gaeilge curriculum adopted a Communicative Language Teaching (CLT) approach, aiming to promote the use of Irish as a living language for communication in a meaningful and engaging manner. Enjoyment was given significant importance in Gaeilge lessons, with many exemplars and teaching materials for teachers incorporating games and paired work activities. However, it should be noted that the Gaeilge curriculum was presented exclusively in Irish, which some teachers found challenging in terms of their understanding of the content (Uí Choistealbha, 2012).

There was minimal overlap between the English and Gaeilge curricula, although there was mention of the transfer of general skills. While teacher guidelines provided exemplars, a specific list of suitable reading materials, as seen in the 1971 curriculum, was absent. Some critics felt that the 1999 curriculum further marginalised reading skills (Hickey and Stenson, 2016), despite efforts to encourage reading development through the Gaeilge curriculum. Reading in Irish was mostly seen as a reinforcement of acquired oral language (Hickey, 2001), and there was no explicit guidance on teaching decoding skills. A subsequent report by the Inspectorate noted the lack of a formal approach to teaching reading skills in Irish (DES, Inspectorate, 2007). The 1999 curriculum explicitly named and addressed various language skills individually, while acknowledging their interrelated nature, a point also emphasised by researchers such as Clay (2001) and Kennedy, Dunphy et al. (2012).

2.3.2 Standards and attitudes

2.3.2.1 Society's outlook on Irish within a diverse community

The Irish language holds a unique and significant place in Ireland, serving as a vital pillar of the nation's identity, culture, and global heritage (Ó Ceallaigh & Ní Dhonnabháin, 2015). Beyond its linguistic function, Irish embodies a profound cultural expression and heritage, playing a crucial role in defining one's sense of self.

As pointed out by Edwards (2009, p. 251), even for English-speaking Irish and Welsh individuals, the emotional connection to a culture and ancestry tied to a language they may no longer speak is a testament to the enduring influence of intangible and symbolic elements. This underscores how language transcends mere communication; it encapsulates a profound link to one's roots.

Notably, for the majority of the population, the Irish language symbolises their national identity, but for those who fluently speak Irish in their daily lives, it assumes a more profound dimension. As highlighted by Nic Eoin (2011, p.135), it becomes an integral part of their national and cultural identity, deeply intertwined with their individual sense of self. This intricate relationship with the Irish language reflects its enduring importance as a symbol of heritage and a personal emblem for those who cherish it.

In a recent study conducted by Murray et al. (2021), the focus is on the role of the Irish language in the school curriculum, aims to explore the intricate link between language and identity within a diverse society. Despite being the official language of Ireland, Irish has historically held a minority position in comparison to the other official language, English. The number of native Irish speakers has steadily declined over time (Ó Giolllagáin, 2016).

Murray et al's. (2021) study is set against the backdrop of evolving demographics in Ireland due to increased immigration (McGinnitty et al., 2018), which has led to a significant rise in linguistic diversity. The period between the 2011 and 2016 censuses saw a 19% increase in residents reporting languages spoken at home other than English or Irish (CSO, 2017). Amongst these changes, the prominent place of the Irish language in primary and secondary school curricula has become a topic of discussion. There are differing opinions on whether upholding the language's central status might hinder the creation of an inclusive and open environment (Ó Laoire, 2012; O'Sullivan et al., 2019). According to findings from Murray et al.'s (2021) research, participants perceive Irish schools to have moved beyond their previous monocultural image. Within this context, the compulsory inclusion of the Irish language in the curriculum has the potential to either limit or enhance cross-cultural understanding. The outcome depends on how the language's importance is presented and understood.

The analysis of attitudes towards the Irish language highlights the influence of political and socio-cultural dynamics in multilingual scenarios. Language shifts reflect broader societal challenges linked to power, identity, and status (Blackledge, 2008). By examining language through the perspective of language ideology, which explores the relationship between language behaviour and broader social structures, we can understand how people's attitudes toward language reflect societal conflicts related to notions of identity and social standing, often linked to differences in power (Warren, 2011).Taking a language ideology perspective helps reveal the hidden socio-cultural and political beliefs that surround language. According to Armstrong (2012), this perspective is valuable because it goes beyond just linguistic proficiency, considering both the social and practical dimensions of language use. Language ideology encompasses a wide range of beliefs, attitudes, and societal norms linked to language, encompassing aspects like identity, ethnicity, history, politics, and language usage (Armstrong, 2012, p. 152).

Fishman (1991) underscores the significance of "ideological clarification" in language revitalisation endeavours. This is especially pertinent for endangered languages, as expressed attitudes about a language might not align with actual language behaviours. Different viewpoints within language revival movements can hold varying ideological perspectives about the language. Successful language revitalisation necessitates addressing disparities between attitudes and behaviours (Hogan-Brun, 2006).

In the Irish context, despite favourable sentiments towards Irish, only a minority regularly use the language, and even fewer consistently employ it with their children at home (King, 2000, p. 167). This inconsistency between attitudes and behaviours presents a challenge. Neglecting to seek ideological clarity could hinder the effectiveness of language revitalisation policies.

Murray et al’s. (2021) findings also contribute to a deeper understanding of the broader issues in language revitalisation and its connection to societal dynamics. By examining the attitudes towards the Irish language, we gain insights into the intricate interplay between language, identity, and culture within the context of a diverse and changing society. The complexities of language attitudes and ideologies shed light on the challenges and opportunities associated with language preservation and revitalisation efforts.

In spite the positive attitude society may have towards the Irish language and governmental initiatives to support the revitalisation of the language, Irish finds itself in a precarious position. A large number of reports and research findings clearly indicate that students in the education system have a low level of proficiency in the language (Mac Donnacha et al., 2005; Department of Education and Skills, 2005, 2007, 2015; Harris, 1988, 1991; Harris and Murtagh, Harris et al., 2006; National Council for Curriculum and Assessment, 2008; Péterváry et al., 2014). The lack of linguistic proficiency among some teachers is well documented (Department of Education and Skills, 2005, 2008; Harris et al., 2006; Mac Donnacha et al. 2005; National Council for Curriculum and Assessment, 2008). This presents a real issue for schools and their efforts to support the Irish language. Many teachers also experience difficulty in implementing a convincing pedagogy (Department of Education and Skills, 2005, 2008; Harris et al., 2006; National Council for Curriculum and Assessment, 2008; Ó Ceallaigh & Ní Dhonnabháin, 2015; Ó Duibhir, 2009; Mac Donnacha et al., 2005; Ní Shéaghdha, 2010).

2.3.2.2 Children's standards in learning Irish and their attitudes towards the language

The changing landscape of early year's education in Ireland, along with the diverse composition of classrooms and variations in children's learning preferences, has significant implications for their experiences with the Irish language (Dunne, 2020). One crucial study on children's experiences of learning Irish under the 1999 revised curriculum was conducted by Harris et al. in 2006. This study found a notable decline in the mastery of language objectives between 1985 and 2002. While the majority of children achieved some level of proficiency in key objectives, there was an increase in the percentage of children who did not meet the language standards. Harris highlighted concerning statistics, such as 65.9% failing in speaking vocabulary, 76.5% failing in verb morphology, and 64.1% failing in the syntax of statements. Only a small number of children in English-medium schools demonstrated high levels of performance, though some children did make progress in these areas, even if they did not reach the intended level for 6th class.

Since the implementation of the 1999 curriculum, there have been some improvements in children's experiences with Irish. Children reported increased enjoyment of Irish lessons and a stronger sense of pride in the language (NCCA, 2008). The Growing Up in Ireland (GUI) study conducted in 2009 indicated that there was no significant decline in children's attitudes towards Irish (Devitt et al., 2018). For example, 74% of children reported that they always or sometimes liked Irish (McCoy et al., 2012). Moreover, children's attitudes towards Irish were found to be similar to attitudes towards Welsh among Welsh children (Pearse, 2015) and attitudes towards minority languages in Spanish autonomous regions (Huguet, 2006).

One positive aspect of learning and teaching Irish in schools is the increased diversity among Irish speakers. The GUI study revealed that English as an Additional Language (EAL) learners generally had a similar disposition towards the Irish language, with no negative orientations reported among this group, possibly due to a lack of exposure to negative attitudes towards Irish at home (Devitt et al., 2018). Parents of migrant children also reported favourable attitudes towards Irish (O'Toole, 2016), and teachers recognised the strengths of EAL learners (Dunne, 2015). Informal observations from the Department of Education and Skills' Inspectorate supported these findings (Department of Education and Skills [DES], Inspectorate, 2007). However, it is worth noting that concerns regarding negative attitudes have not been entirely addressed, as some issues still exist regarding children's attitudes towards learning Irish. McCoy, Smyth, and Banks (2012) found that children had less favourable views of Irish compared to reading and mathematics, with only one-fifth of children reporting that they always liked it. Boys were reported to be more disengaged than girls. Nevertheless, interventions aimed at increasing engagement have shown promise in narrowing the gender gap (e.g., Dunne & Hickey, 2017).

2.3.2.3 Teacher's standards in teaching Irish and their attitudes towards the language

According to a report by the Department of Education and Skills (DES) in 2007, about 25% of primary school teachers in Ireland were found to have inadequate proficiency in the Irish language based on Whole School Evaluations and incidental visits. Additionally, nearly half of the observed classes were rated as having poor or fair teaching standards. Furthermore, approximately one-third of classrooms taught Irish using English as the medium of instruction, limiting children's exposure to Irish as a living language.

The report highlighted challenges faced by teachers in structuring oral language lessons, with a focus on introducing new nouns without providing enough opportunities for contextual practice (DES, 2007). Although students enjoyed language games, the actual learning outcomes were unclear. The report emphasised that improved proficiency in Irish was associated with more effective teaching methods. However, most schools showed weaknesses in their overall planning for Irish language instruction, with insufficient attention given to utilising differentiated teaching approaches and varied methods.

The Chief Inspector's Report for 2010-2012 revealed less favourable results for Irish language instruction compared to English or mathematics. Approximately 20% of the observed lessons had problematic teaching, and pupils' learning of the language faced difficulties in around 24% of those lessons.

The proficiency and fluency of teachers in Irish had a significant impact on the quality of language instruction. Many primary schools needed to change their approach to teaching Irish, with lessons lacking opportunities for children to learn through conversation and discussion. Teachers also struggled with providing language-rich experiences and assessing children's progress in Irish (Dunne, 2020).

The Chief Inspector's Report for 2013-2016 reiterated the same issues, with a decline in the teaching of Irish compared to English and mathematics. Some teaching methodologies in Irish lessons tended to be traditional, leading to limited opportunities for group work and hindering children's communication skills.

A study by Harris in 2008 on teachers' attitudes towards teaching Irish in English-medium schools showed a decline in positive attitudes over time. The reduction in teaching hours for Irish under the 1999 curriculum was considered a contributing factor to the decline in student achievement, as some primary teachers may not allocate the prescribed time for teaching Irish due to their discomfort with the language. This lack of time and effort dedicated to teaching Irish was noted to affect its use beyond the designated Irish slot in the school schedule.

2.3.3 An integrated approach to language learning - The Primary Language Curriculum

The Primary Language Curriculum (PLC) is currently being implemented in primary classrooms, and it shares similarities with similar developments in Canada, Wales, and Scotland (Dunne, 2020). The curriculum emphasises a holistic view of a child's linguistic abilities, rooted in a communicative approach to language learning that recognises the importance of the social dimension of communication. This focus on communication is particularly valuable, considering a Chief Inspector's Report, which found that Irish lessons provided fewer opportunities for talk, discussion, and group work compared to other subjects. One distinctive aspect of the PLC is its aim to cater to children of all abilities in today's diverse classrooms. It acknowledges the differences in the profile of primary school children, including the increased diversity of languages and cultures present in Irish classrooms.

Many children in the current school-going population have benefited from early years education facilitated by the Government's free Early Childhood Care and Education year introduced in 2010 (Dunne, 2020). These children may have exposure to elements of Aistear, the early childhood curriculum framework, and be more familiar with learning through play and early literacy activities before starting formal schooling, potentially being further along their progression milestones. Some of them may have also attended naíonraí or Irish-medium early childhood education settings. Additionally, the curriculum recognises the presence of home languages other than Irish or English and acknowledges the linguistic resources that these children bring to school (Government, 2019). The relationship between learning Irish and learning a third or fourth language is also acknowledged.

The PLC provides two versions of the curriculum, one for English-medium schools and one for Irish-medium schools. In the introduction to the PLC, differences between this curriculum and the previous 1999 curriculum are outlined. The main shift is a focus on the child's learning rather than the teacher's teaching, presenting learning as a continuum rather than fixed outcomes for all children. This addresses a weakness identified in previous assessment approaches. The curriculum offers support materials that provide concrete examples of children's learning corresponding to specific milestones.

The PLC also emphasises an integrated approach to language learning and highlights the importance of the school context. It reinforces the principles of Communicative Language Teaching (CLT), which emphasises meaningful interaction in the language among children. The curriculum acknowledges the differences between children learning English as their first language and those learning Irish as a second additional language, underlining the critical role that schools play in exposing generations of children to the Irish language.

In accordance with Shiel at al. (2012) developmental perspective on language learning, the PLC incorporates a Progression Continua for each strand as a supportive tool. These continua provide indicators of language progression that teachers can employ to enhance their instructional practices. The Learning Outcomes within the Primary Language Curriculum describe the expected learning and development outcomes for children within a specific timeframe (Government of Ireland, 2019). To assist teachers in utilising these outcomes effectively and providing activities and experiences that facilitate children's language learning, the Progression Continua provide detailed descriptions of various aspects of the Learning Outcomes. It recognises that children may be at different stages of the continua for different Learning Outcomes and strands of the curriculum, reflecting the intricate nature of language learning. Furthermore, children may move both forward and backward along the Progression Continua, allowing for a flexible and dynamic learning process which aligns with an SCT approach to learning (ibid).

2.3.3.1 Content and Language Integrated Learning (CLIL)

Children in all classrooms learn at a different pace and teachers differentiate accordingly for the children in their classrooms. This is highlighted in section 2.2.7 when we consider a child's journey through the ZPD. Research on SLL also indicates that learners acquire a second language at very different rates, and many studies have examined the factors that might explain this (Larsen-Freeman, 2011). Some factors, include age, learning strategies, learning styles, attitude, motivation, aptitude, and personality, have all been shown to have an impact on language learning (Ó Duibhir & Cummins, 2012). This highlights that instruction is not only about teaching a language but also about teaching children (Ó Duibhir & Cummins, 2012). The teacher must take account of individual differences in children and their approaches to learning. Some instructional approaches to language teaching have focused on providing a context for language learning and language use through the design of task-based activities (Van den Branden, Bygate, & Norris, 2009) or by the integration of content and language through Content and Language Integrated Learning (CLIL) approach (Dalton-Puffer, 2011).

The CLIL approach has been defined as "a dual-focused educational approach in which another language is used for the learning and teaching of both subject content and language" (Coyle, Hood, & Marsh, 2010, p. 1). It involves teaching another curriculum subject or aspects of another subject through a second language. Ireland has taken steps towards the inclusion of CLIL in English medium schools to support the teaching and learning of Irish. In 2017, the Minister for Education in Ireland announced a ten-year plan to focus on a ten-year strategy for teaching foreign languages in primary and post-primary schools. It was highlighted that the teaching of Irish from the early years of primary means that children become familiar with bilingualism from age 4 and they start to learn second language skills early (Department of Education, 2017). The strategy aimed to investigate the possibilities of using CLIL techniques in the classroom "by teaching aspects of the primary curriculum through Irish and foreign languages which will equip learners with transferrable language skills.” It was also highlighted that “research shows that teaching languages as a means of communication in this way, rather than as an academic subject to be learnt in isolation, can be very effective” (Department of Education, 2017). More recently, the Department of Education has established a pilot project to support the CLIL approach in primary schools (Department of Education, 2019).

There is a limited amount of research on Content and Language Integrated Learning (CLIL) for young learners aged 3-6 years (Mair, 2020). This lack of research in preschool CLIL may be because some researchers perceive little difference between early year’s immersion programs and CLIL, or because they believe that CLIL is not suitable without a subject-based curriculum. However, the widespread use of the CLIL label at the preschool level indicates the need for more research. Until more classroom data becomes available, it is challenging to draw definitive conclusions about the benefits of CLIL for very young learners (Mair, 2020).

The few documented CLIL preschool programs tend to have low exposure approaches (Mair, 2020). Some examples of such low exposure preschool CLIL programs, as found in research, are programs in Cyprus (Ioannou-Georgiou 2015), Spain (García Esteban 2015a, b), Italy (Mair 2018), and Finland (Pynnönen 2013). The absence of higher exposure programs may be due to the experimental nature of these programs or a lack of resources to support more intensive implementations.

Many of the documented preschool CLIL programs use a modular base, interdisciplinary, themed, or "language shower" approaches (Mair, 2020). According to Marsh (2012), these approaches are considered “practical and theoretically sound” for introducing CLIL, especially for very young learners. "CLIL Showers" refers to a form of micro-immersion in which children receive limited exposure to the target language in short daily sessions, particularly in the early stages. Such programs, as defined by Bentley (2015), fall under the category of "soft CLIL," which involves lower exposure approaches compared to "hard CLIL," where up to 50% of the curriculum is taught in the foreign language. Marsh (2012) recommends giving special attention to preschool in the context of low exposure "soft" CLIL programs. According to Marsh (2012) these programs are not designed to achieve bilingual language proficiency but instead aim to enhance oral receptive ability, promote initial productive ability, and lay the foundation for language learning in subsequent school levels, as well as foster language awareness. Additionally, they may aim to facilitate continuity from preschool to primary education by providing a consistent approach and curricular continuity between these levels.

Furthermore, stories can serve as effective tools for children to develop key principles encompassed within a CLIL approach, including language, content, communication, cognition, and culture (Mair, 2020). Stories can naturally and meaningfully introduce specific language related to content areas within a CLIL perspective. For young learners, stories offer a valuable means of contextualizing and introducing new language, making it understandable and memorable. These stories often relate to daily life experiences, children's emotions and memories, and cultural and intercultural values, enriching the classroom environment. They cover various topics directly relevant to curricular content, such as animals, family, traditions, emotions, environment, history, and experiments. Linguistically, stories present grammar, vocabulary, and formulaic speech in a structured context that supports comprehension of both the narrative world and the related content. Reading or listening to a story provides a joyful experience in immersing oneself in the sounds and visual aspects of a new language. Stories frequently revolve around interesting topics that can help present, practice, consolidate, or expand children's knowledge in specific thematic areas related to school subjects. Stories serve as excellent resources in a CLIL context to stimulate children's responses to meaning, content, and form. According to Ioannou-Georgiou & Verdugo (2011), they motivate learners to participate in the classroom, repeat certain phrases, engage in role-play, and express their thoughts and emotions. Stories also provide opportunities for children to retell the story and even create alternative endings Ioannou-Georgiou & Verdugo (2011).

2.3.3.2 Play, a meaningful context for second language learning

Play is a highly meaningful context for language learning, as it provides children with rich opportunities to develop and use language in a natural and engaging way (NCCA, 2004). According to Bruce (2001), play is considered the "highest form of learning in early childhood," highlighting its significance in fostering language development. Through play, children engage in various types of language-based interactions, allowing them to enhance their communication skills and expand their vocabulary.

During play, children engage in imaginative and socio-dramatic activities, where they use their developing language skills to move from thinking in real terms to thinking in the abstract (Hutt, 1979). This ludic type of play allows children to engage in pretend play, role-playing, and storytelling, enabling them to explore different narratives, express their ideas, and use language in creative ways. Through these language-rich play experiences, children practice communication, narrative structure, and language comprehension, enhancing their linguistic abilities (Bruce, 2001).

Play also serves as a context for children to develop a language for various purposes, including expressing their feelings, ideas, and thoughts (NCCA, 2004). Through play, children engage in conversations, negotiate roles and scenarios, and use language to problem-solve and collaborate with others. These interactions require children to use language in meaningful contexts, promoting their language fluency, pragmatics, and social communication skills.

The presence of an adult in the play environment can greatly support children's language learning experiences. Pyle and Danniels (2017) highlight that adults can play various roles during play, such as being a commentator, co-player, questioner, or model for new ways of using and interacting with resources (Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013; Tsao, 2008; Weisberg, Zosh, Hirsh-Pasek, & Golinkoff, 2013). The adult's role is to enhance the child's learning experience and provide scaffolding, ensuring that the child is actively engaged and encouraged to use language effectively (NCCA, 2004).

Furthermore, play offers children the opportunity to develop and refine their cognitive and problem-solving abilities through language. As children engage in play, they use language to reason, create working theories, and solve problems (NCCA, 2004). Through discussions and negotiations with peers or adults, children learn to think critically, analyse ideas, and communicate their thoughts effectively. These cognitive processes foster their logical thinking, concentration, and perseverance (Moyles, 1989).

It is important to note that play-based language learning is not limited to child-led practices. Play can also be planned and led by teachers, providing intentional language learning experiences (Government of Ireland, 2019). In this context, the teacher's role is to facilitate and guide children's play experiences, creating opportunities for language-rich interactions and supporting language development (Pyle & Danniels, 2017).

Play serves as a highly meaningful context for language learning in early childhood. Through play, children engage in imaginative and socio-dramatic activities, fostering language development through storytelling, role-playing, and creative expression. Language-rich play experiences allow children to practice communication skills, expand their vocabulary, and develop language fluency. The presence of adults during play provides support and scaffolding, enhancing children's language learning experiences. By actively engaging in play, children develop cognitive abilities, problem-solving skills, and logical thinking, all of which contribute to their overall language development (NCCA, 2004).

2.3.3.3 Translanguaging

The Primary Language Curriculum (PLC) emphasises the comprehensive linguistic abilities of children and encourages connections between different languages (2019). Throughout the curriculum, a link symbol is used to indicate where skills can be transferred between the first and second languages of the school. For example, in English-medium schools, conventions of text explored in English can be further developed in the Irish-language curriculum (Ó Duibhir & Cummins, 2012). Translanguaging is a concept that aligns with new ideas related to multilingualism (Cenoz & Gorter, 2017) and has been employed as a language pedagogy in bilingual settings, like English and the minority language Welsh (Lewis, Jones & Baker, 2012). Initially, it was defined as a bilingual pedagogy that systematically alternates languages for input and output (Cenoz & Gorter, 2017). Menken (2023) highlights that the traditional view of language is that it is a 'system of standardized, static structures' with which you listen, speak, read and write. A translanguaging perspective is that 'language practices are fluid and flexible', indicating that a multilingual person's languages are deeply intertwined.

The concept of translanguaging has evolved to encompass the entire linguistic repertoire of multilingual speakers, integrating both their home and additional languages as resources for communication and meaning making (Devitt & Ó Murchadha, 2021). There is a growing recognition in classroom pedagogy of the value in using multiple languages rather than keeping them separate (Moriarty, 2017; Cenoz & Gorter, 2015, 2017; Blackledge & Creese, 2010; Duarte, 2019, Devitt & Ó Murchadha, 2021). A student's dominant language (L1) has the potential to contribute to the development of their other languages (Baker, 2019).

While translanguaging has gained popularity in various language contexts, its applicability to teaching Irish may face limitations. Research suggests that there may be a tendency to switch to English, reducing children's exposure to Irish during the school day, which is already limited (Nic Pháidín, 2003; Ó Brolcháin, 2017; Ó Curnáin, 2009). Teachers of Irish have expressed reluctance to adopt this approach, as schools are seen as a protective environment for the minority language (Ó Duibhir, 2018; Ó Brolcháin).

However, in the context of English-medium education in Ireland, it is proposed that a combination of monolingual and translanguaging approaches may be more effective in supporting learners to access and utilise their existing language repertoire in learning and acquiring Irish (Moriarty, 2017). Similar to the case of Welsh, where English serves as the supporting language for the majority of children learning Welsh, some children in English-medium schools in Ireland also access a home minority language(s) (Moriarty, 2017; Ó Laoire, 2005). Irish as highlighted in Section 2.3.2, finds itself in a difficult position whereby there is a general respect for the language and it forms part of the nation’s identity however it is not being spoken (Murray et al., 2021). Translanguaging presents an opportunity to support language revitalisation.

There is a concern amongst language teachers that the minority language or heritage language would suffer if a translanguaging model is adopted. Menken (2023) highlights that with such a diverse society and with children coming into classrooms with a wide range of languages there is a need to take a more multilingual perspective to language learning and teaching. Traditional language teaching follows a structured timetable of one hour slots. Menken (2023) advises that when adopting translanguaging, planning is of the utmost importance. The sociolinguistic reality of the classroom is complex and there is a need to reflect on how this practice is attending to the student’s language learning.

The concern over translanguaging in the context of regional minority languages extends to pedagogical translanguaging in Wales. Jones and Lewis (2014, 168) explain that in predominantly English-speaking areas, translanguaging has to be controlled because ‘there is a growing concern that allowing the use of English texts for translanguaging purposes might be a stepping-stone for introducing more of the majority language (English)’ (Cenoz and Gorter, 2017). Menken (2023) advises creating “spaces” within the learning environment for translanguaging. This allows students the opportunity to pull on their diverse linguistic repertoire during certain activities or curricular areas within impacting the language class.

2.4 Conclusion

This section introduced Sociocultural Theory (SCT) as the framework guiding this study. By exploring various constructs of SCT, an understanding of the importance of mediation through tools, cultural artifacts, and social interactions was established. The significance of regulation and internalisation, as well as the scaffolding provided by teachers or More Knowledgeable Others (MKOs) within a child's Zone of Proximal Development (ZPD), are emphasised. Within a sociocultural framework, second language (L2) development can be seen as the process through which a child acquires more effective language-mediating skills and gains voluntary control over their ability to think, analyse, and act using their L2. As children become less reliant on external support for their language development, they become more autonomous and independent language learners (Lantolf et al., 2015, p. 4).

Language learning is influenced by multiple interacting factors. The emergentist theory suggests that children learn language along a continuum of learning, and in second language acquisition, the transfer of skills from the first language to the second language is considered essential. The various interpretations and theories surrounding play provide insights into its significant role in children's learning. Communication lies at the heart of play, and the social aspect of play is crucial for children's development and communication skills.

Active engagement with the target language is crucial for children's language learning, and the role of teachers in creating opportunities for communication is paramount. Incorporating technological tools can further enhance language learning experiences by providing interactive platforms for meaningful language use. This study aims to explore how one such technological tool can promote active oral language engagement among children, fostering their motivation and proficiency in the target language.
The following section will review the role of programmable floor robots in education and their potential for fostering Computational Thinking (CT) skills.

3 Computational Thinking and Robotics

As outlined in chapter 2 this investigation brings language learning and technology together in a play activity in a junior infant classroom. This chapter looks at the second part of the theoretical approach, which is constructionism. Originating in Jean Piaget's constructivism, Seymour Papert's constructionism situates children's learning in the concrete using tangible technological manipulatives, i.e., robotics (1980). This chapter will also look at CT skills, which can be developed using technological tools, their relevance today, and how they can be introduced to young children in a practical way. The final part of this section will look at the overlap between the use of robotics to develop CT skills and coding as literacy.

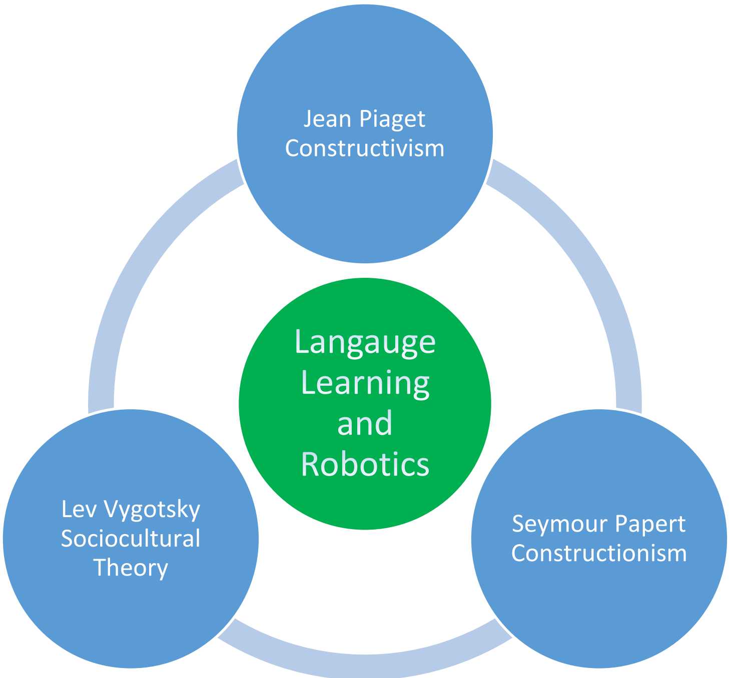


Figure 3 Contributing theories for this investigation

3.1 The journey from constructivism to constructionism

> A constructionist approach to teaching gives children the freedom to explore their own interests through technology *(*Bers, 2008b*).*

Constructionism was developed from the theory of constructivism. Constructivism is broadly defined as a philosophy of learning in which each individual constructs knowledge based on their own experiences through social interactions with others. During the 20th and 21st centuries, constructivism became more complex with the development of social constructivism, psychological constructivism, and radical constructivism. Each of these approaches reflects varying degrees to which knowledge can be socially constructed by an individual (Given, 2008). John Dewey's investigation of the nature of human experiences and interactions with their environment might be considered as constructivist considering his recognition that knowledge is constructed in social contexts and that children need to be active learners and not passive recipients of knowledge. Piaget's theory of cognitive development (1936) is also considered constructivist in that through activity a child constructs their understanding of the world around them. As previously mentioned, Vygotsky's SCT outlines that a child develops higher mental functions through interactions with adults and their peers (ZPD). Through these interactions a child learns language and constructs knowledge specific to his or her culture or learning environment. This evolution of the constructivism paradigm led to Seymour Papert's constructionism.

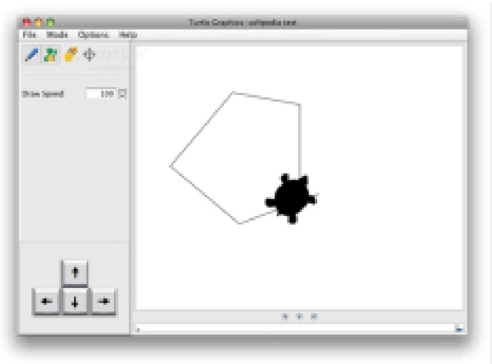
Constructionism is a learning theory that posits that knowledge is best acquired when children actively engage in building their own meaningful constructions. Derived from Piaget's theory, Papert's constructionist approach emphasises how real-world construction leads to mental constructions or ideas in the mind, similar to Vygotsky's concept of internalisation. The effectiveness of this approach is realised through learning by making, where learners actively construct with real-world artifacts or tools.

An essential aspect of constructionism is the focus on "objects-to-think-with" – objects that encompass cultural presence, embedded knowledge, and the potential for personal identification (Papert, 1980, p. 11). This approach not only facilitates knowledge building through learners' experiences and commitment to creating artifacts but also enhances the social environment. Learners develop a sense of belonging to a group with a common goal, making learning significant for everyone and fostering connections within the learning culture (Papert, 1980).

The core idea of constructionism is that the most effective learning experiences involve creation, socially meaningful artifacts, interaction with others, and the use of elements that support one's own learning and thinking.

Seymour Papert developed the theory of constructionism in the 1960s while working as a mathematician and director of the MIT LOGO group. LOGO, a programming language for children, was a result of his collaboration with Wally Feurzeig, Daniel Bobrow, and Cynthia Solomon. Known for its use of turtle graphics on-screen or with a robot resembling a turtle, LOGO aimed to place the child at the centre of the activity as a programmer, creator, discoverer, and producer of meaningful projects. It became popular due to the rise of personal computers in the late 1970s.

Despite the initial vision for LOGO, there were concerns that its purpose could be compromised when used in classrooms employing an instructionist pedagogy. To address this, a pedagogy for utilising LOGO in line with the constructionist vision was developed, providing the foundation for robotics in education.



LOGO turtle on the screen
https://www.robotlab.com/blog/seymour-papert

A physical LOGO turtle robot
Mindstorms

Figure 4 Seymour Papert's LOGO

The theory of constructionism was based on Jean Piaget's theory of constructivism. Constructivism is a theory that learning is an active and constructive process (Piaget, 1945). Children construct knowledge and meaning from their own learning experiences. Piaget's theory is based on knowledge being constructed in the child's mind. Piaget's perspective indicates what children are drawn to and interested in what they can achieve at different stages in their development. The theory of constructivism outlines the way children do things and how the way they think evolves over time or in stages. This incremental stage of development was previously mentioned in section 2.3.1. Constructivism indicates the development of thought processing where children hold on to their views rigidly, and when they are ready, they will let them go and develop a deeper understanding. Piaget indicates that children have strong reasons for not letting go of their views just because someone else, such as their parent, might tell them they are wrong. Children have their own perspectives on the world around them, which are developed through their experiences, whether that is at home, in school or living everyday life. Their logic on the world is developed through these experiences. Their perspectives are continuously evolving as they move through different stages of development. Piaget's four stages of development (the sensorimotor stage, preoperational stage, concrete operational stage, and formal operational stage) have had a significant impact on curriculum development over the years and its implementation. According to Ackermann (2001) the implications of such a view for education are threefold:

1. *Teaching is always indirect. Children don't just take in what's being said. Instead, they interpret what they hear in the light of their own knowledge and experience. They transform the input.*

2. *The transmission model, or conduit metaphor, of human communication, won't do. To Piaget, knowledge is not information to be delivered at one end and encoded, memorized, retrieved, and applied at the other end. Instead, knowledge is an experience that is acquired through interaction with the world, people, and things.*

3. *A theory of learning that ignores resistance to learning misses the point. Piaget shows that indeed children have good reasons not to abandon their views in the light of external pressures.*

Piaget's theory, while fundamental in outlining the different stages of development of a child's thinking, overlooks the role of the environment, use of media and individual preferences or styles in learning and development. This is where Piaget and Papert's theories complement each other. Papert's theory of constructionism has built upon Piaget's constructivism.

> *"Constructionism—the N-word as opposed to the V-word— shares constructivism's view of learning as "building knowledge structures" through progressive internalization of actions… It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sandcastle on the beach or a theory of the universe*
>
> *(*Papert & Harel, 1991, p. 1*)*

The focus for Papert is on learning through construction instead of the overall cognitive potential. Papert how ideas are formed and developed when expressed through different media, when realised in particular contexts and when worked out by the child (Ackermann, 2001). The focus moves from looking at a group of learners to looking at individual learner's conversations with their artifacts or objects-to-think with. For Papert, expressing ideas is an important part of learning. By expressing ideas, it makes them tangible, and they can be shared, which in turn leads to a conversation where ideas can be discussed and developed. Similar to Vygotsky, Papert's artifacts or tools assist in the mediation for learning. Papert (1980) developed this by focusing on how internal constructions can be supported by real-world constructions, including the use of robotics. Children learn by doing. The child, during constructionism, actively constructs or creates knowledge rather than acquires it. Similar to Piaget, Papert identifies learning as the construction and reconstruction of knowledge through experience. Children construct knowledge, and their questioning is based on personal experiences. The child continuously tests this through social negotiation or conversations with their teacher and peers. Each child has a different interpretation or construction of knowledge. They bring their own set of cultural experiences to the classroom environment. A misunderstanding of constructionism is that teachers should not tell or teach children anything directly but should let them figure it out or construct it for themselves. Constructionism assumes that knowledge is constructed from what the child already knows, and so even if they are being taught something new in class, they are constructing new knowledge as part of a consolidation process. As previously mentioned in section 2.4.1, this process is similar to Piaget's 'accommodation' and 'assimilation.'

Papert was always reluctant to give constructionism a definition. In 1991 he wrote,

> "It would be particularly oxymoronic to convey the idea of constructionism through a definition since, after all, constructionism boils down to demanding that everything be understood by being constructed" (Papert & Harel, 1991).

While respecting this, Bers (2008) a former student of Papert's offers four basic principles of constructionism for early childhood education

1. Learning by designing personally meaningful projects to share in the community;
2. Using concrete objects to build and explore the world;
3. Identifying powerful ideas from the domain of study;
4. Engage in self-reflection as part of the learning process.

These principles, agree with the early childhood perspective of "learning-by-doing" and engaging in "project-based learning" (Bers, 2020). Constructionism offers an extension to the early childhood perspective by engaging children in "learning by designing" and "learning by programming." Bers (2008a) outlines a continuum of learning opportunities that span from wooden blocks to robotics.

Papert's constructionism became widespread in the 1980s as he advocated that children become programmers to learn about mathematics and to learn about learning. While Papert was a mathematician, he was convinced that the benefits of learning to programme went far beyond just mathematics. Through designing and debugging programs, children could develop a reflective approach to problem-solving and learning. The theory of constructionism suggests that the use of objects or tangible manipulatives such as robotics can be powerful for education when they are supporting the design, construction, and programming of personally and epistemologically meaningful projects (Bers, 2008a; Papert, 1980; Resnick, Bruckman, & Martin, 1996). Personally meaningful projects are those projects which children choose to engage and work on because they are interested in them. An epistemologically meaningful project is one that engages learners in exploring disciplinary knowledge as well as the nature of knowledge. A personally meaningful project is not a new concept to the early year's classroom as teachers consider the interest of the child as well as the community or classroom in which the learning happens. The classroom supports the child in their learning, scaffolds their learning and provides interesting objects that the children can share with each other. Papert recognised at an early stage the importance of powerful technological tools for supporting the development of concrete projects, which children truly care about.

3.2 From Theory to Practice

Computational Thinking (CT) is a term that has resurfaced widely in the last 15 years. Papert (1980) introduced the term CT along with his colleagues while developing LOGO. Its aim was to help children think in computational ways. It meant solving problems algorithmically and developing technological fluency. "Children who could think like a computer could use a computer in a fluent way." Jeanette Wing brought CT back to the forefront of research conversations in 2006. She made a call that CT should be added: "to every child's analytical thinking." This revival in interest proposed that the problem-solving strategies traditionally used by computer scientists could have broader applications. Looking to Papert, there can be a broader argument identified for its importance "certain uses of very powerful computational technology and computational ideas can provide children with new possibilities for learning, thinking, and growing emotionally as well as cognitively" (Papert, 1980). Wing (2006) theorised CT as a problem-solving approach that draws on concepts that are fundamental to computer science by "reformulating a seemingly difficult problem into the one we know how to solve, perhaps by reduction, embedding, transformation, or simulation" (Wing, 2006, p. 33). CT involves breaking down problems, using algorithms to solve problems, and abstracting and automating the problem-solving approach (Yadav, Good, Voogt, &

Fisser, 2017). Even though CT includes a “range of mental tools that reflect the breadth of computer science,” Wing argued that CT represents “a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use,” (Wing, 2006, p. 33). Though Wing’s (2006) article promoted the term “computational thinking”, Denning (2009) outlines how CT has had a long history in computer science since the 1950s, when it was known as “algorithmic thinking”. More recently, Papert linked the practice of computer science to the act of thinking, which became a central theme of his work with the LOGO programming language (Papert, 1980; Papert & Harel, 1991). Papert saw the children’s creation of “microworlds” in LOGO as an “epistemological apprenticeship” (Papert, 1980) to help develop children’s thinking and problem-solving abilities. Papert believed that the LOGO environment provided children with opportunities to program the computer, which “could contribute to mental processes not only instrumentally but in more essential, conceptual ways, influencing how people think even when they are far removed from physical contact with a computer” (Papert, 1980, p. 4). In the conceptualisation of CT, attempts have been made to shift the focus from the programming tools to the actual thinking skills Papert’s methods were hoping to enhance.

3.3 Computational Thinking – finding a consensus

The CT field of research is filled with debate on how to define it and what might be included under the umbrella of CT. As previously mentioned, the concept of CT in education, can be traced back to the work of Papert (1980, 1996). When Jeanette Wing reintroduced the term 'computational thinking’ in 2006 she not only revived the term but offered an outline of what CT includes (Wing, 2006, p. 33).

> “Computational thinking involves solving problems, designing systems, and understanding human behaviour by drawing on the concepts fundamental to computer science. Computational thinking includes a range of mental tools that reflect the breadth of the field of computer science.”

Since the publication of Wing's influential article, many other researchers have strongly argued for the importance of CT as a fundamental literacy for 21st-century education and its applicability to all educational levels from pre-primary education to higher education (Barr & Stephenson, 2011; Bundy, 2007; Grover & Pea, 2013; Guzdial, 2008; Lu & Fletcher, 2009; Shute & Asbell-Clarke, 2017). Recognisable CT skills include, among others, abstraction, decomposition, and algorithmic thinking (Council, 2010; Selby & Woollard, 2013; Wing, 2008). In 2010, the US National Research Council (NRC) organised a “Workshop on the Scope and Nature of CT” with key international researchers, including Wing. One outcome was the evident lack of consensus on basic definitions. Participants expressed differing views about the scope and nature of CT. In 2011, to move the discussion forward, Wing proposed a new definition of CT:

> *“Computational thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent, i.e., a human, a computer, or a combination of both, using tools and techniques from computer science.” (p. 1).*

Two aspects emerge from this definition that is particularly significant for education:

1. CT is a thought process, and so it is independent of technology.
2. CT is a specific type of problem-solving that entails distinct abilities, e.g., being able to design solutions that can be executed by a computer, a human, or a combination of both.

Wing’s definition has subsequently become a reference point for discussion on CT. This notwithstanding, other distinct definitions have emerged in the literature. Among the most cited of these is the definition the Royal Society proposed in 2012 (p. 29), which emphasises that computation is not exclusively a human construct but is also present in nature.

> *“Computational thinking is the process of recognising aspects of computation in the world that surrounds us and applying tools and techniques from Computer Science to understand and reason about both natural and artificial systems and processes.”*

The Computer Science Teachers Association and the International Society for Technology
in Education (CSTA & ISTE, 2014) have developed an operational definition that serves as another significant reference point. This lists all the operations that constitute CT as a practice. CT is a problem-solving process that includes (but is not limited to) the following characteristics:

- Formulating problems in a way that enables us to use a computer and other tools to help solve them;
- Logically organising and analysing data;

- Representing data through abstractions such as models and simulations;
- Automating solutions through algorithmic thinking (a series of ordered steps);
- Identifying, analysing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources;
- Generalising and transferring this problem-solving process to a wide variety of problems (CSTA & ISTE, 2014).

CT, as is evident from the literature, has become a popular term in computer science education, with definitions varying depending on perspective (Tedre & Denning, 2016). There are three types of approaches to defining CT. It is a set of skills to help solve problems (Wing, 2006), it is a thought process (Aho, 2012), or it is a problem-solving process (Voogt, Fisser, Good, Mishra, & Yadav, 2015). Wing (2008) stated in her refined definition of CT that it is an approach for solving problems that draws upon concepts fundamental to computing. Later, Aho (2012, p. 832) described the term CT as including "algorithm-design and problem-solving techniques that can be used to solve common problems arising in computing". Yadav et al. (2017) remind us of Wing's initial paper (Wing, 2006) that CT involves three key elements Algorithms, Abstraction, and Automation. Settle and Perković (2010) proposed seven principles for CT across the curriculum, adding that CT also involves computation, communication, coordination, recollection, evaluation, and design. For Lee et al. (2011) CT involves defining, understanding, and abstraction. Barr *et al.* (2011) suggested that CT involves the design of solutions, implementation of designs, testing, running, analysing, reflecting, abstraction, creativity, and group problem solving. Grover and Pea (2013) and Grover and Pea (2018) posit that CT should include among others abstraction, information processing, structured problem-solving decomposition as modularisation, iterative recursive thinking, and efficiency.

The list or perspectives on defining CT are long and tedious with a polarisation of various perspectives. According to Brennan & Resnick (2012), CT involves three dimensions: computational concepts (the concepts designers employ as they program), computational practices (the processes of construction), and computational perspectives (the perspectives designers form about the world around them and about themselves). In August 2016, the CSTA released the [Interim] CSTA K–12 Computer Science Standards. This update to existing CSTA standards refers to Wing's (2016) CT definitions and stresses the problem-solving aspects, as well as abstraction, automation, and analysis distinctive elements of CT:

> *"We believe that computational thinking is a problem-solving methodology that expands the realm of computer science into all*

disciplines, providing a distinct means of analysing and developing solutions to problems that can be solved computationally. With its focus on abstraction, automation, and analysis, CT is a core element of the broader discipline of computer science" (p. 6).

Numerous papers study the potential advantages of introducing CT in education. The belief is that CT can enable children to think in a different way while solving problems, to analyse everyday issues from a different perspective, to develop the capacity to discover, create and innovate, or to understand what technology has to offer (Allan et al., 2010; Lee et al., 2011). Kolodner believes that CT is a set of skills that transfers across disciplinary domains (NRC, 2011, p. 54). In Resnick's view, CT is not simply a way to learn problem-solving skills but also a means for expressing oneself with digital media. This means that CT capacities are needed for design and social cooperation (NRC, 2011, p. 68). Different authors suggest a wide variety of skills related to CT acquisition, such as:

- problem-solving, examining data patterns and questioning evidence (Charlton & Luckin, 2012);
- collecting, analysing, and representing data, decomposing problems, using algorithms and procedures, making simulations (Gretter & Yadav, 2016);
- using computer models to simulate scenarios (Creative Learning Exchange, 2015); dealing with open-ended problems and persisting in challenging cases (Weintrop et al., 2016) et al., 2015);
- and reasoning about abstract objects (Armoni, 2010).

Barr and Stephenson (2011) proposed nine core CT concepts and capabilities, which are data collection, data analysis, data representation, problem decomposition, abstraction, algorithms and procedures, automation, parallelisation, and simulation. Barr and Stephenson (2011) further asserted that given the importance of computing in the lives of children and how many of them will work in fields influenced by computation, it is critical that we begin to engage them in using algorithmic problem-solving and computational tools. Barr and Stephenson (2011). While CT has gained such popularity, advocates have been plagued by uncertainty, and it "has been criticized for vagueness, ambiguous definitions and visions of Computational Thinking, and arrogance, as well as for bold, unsubstantiated claims about the universal benefit of Computational Thinking" (Tedre and Denning 2016, p. 120).

The CT skills outlined above are not only skills that only computer scientists' value, but, as mentioned previously, skills that can be transferred to any domain, such as literacy, art, journalism, biology, engineering, mathematics, science, and many more (National

Research Council, 2010; Selby & Woollard, 2013). Despite the fact that researchers have strongly argued for the importance of integrating CT in the education of children starting from early childhood, the investigation of the development of young children's CT remains at its infancy (Bers, Flannery, Kazakoff, & Sullivan, 2014; Botički, Pivalica, & Seow, 2018).

The research on CT has served to identify and highlight a range of skills associated with CT that can be tied to practices in primary and post-primary classrooms. It is widely accepted that CT is a thought process that utilises the elements of abstraction, generalisation, decomposition, algorithmic thinking and debugging (Angeli et al., 2016). Researchers have also identified a range of dispositions or attitudes which they claim are integral to the development of CT skills. A number of implementation frameworks have also been put forward. While most of these frameworks focus on post-primary and third level, a small number have been presented for primary level (Angeli et al., 2016), Berry, (2015), Brennan & Resnick (2012), Curzon, Dorling, Selby & Woollard (2014), Selby, Dorling & Walker (2014), ISTE, (2011), F. R. Sullivan and Heffernan (2016).

As there is no one consensus on what skills should be included in such a framework, it leads to an interpretation of the term, the resources available and the age of the children. Across these frameworks, one of the most frequent methods of providing the opportunity to engage in CT skills in primary classrooms is through the use of programming languages such as Scratch (Brennan & Resnick, 2012), ScratchJr (Portelance, Strawhacker, & Bers, 2016), KIBO robotics (Sullivan & Bers, 2015) and Bee-Bot (Angeli et al., 2016). These frameworks and tools are applicable to the early years of primary but require time for integration into the classroom environment. The age of the children is a factor in choosing a CT framework. While at the age of five, children may not be able to abstract information without scaffolding from their teacher at age ten, they may be able to achieve abstraction to a very high level without support. Accordingly, in this study, scaffolding is expected to play a significant role in the development of children's CT skills during learning with Bee-Bot. Unlike KIBO, Bee-Bot does not provide a visual representation of the commands children use to program it. Bee-Bot’s limitations, along with the challenge of young children’s memory skills (Anderson & Jeffries, 1985) may impose a cognitive overload on children's memory resources and therefore create a need to find effective ways to appropriately scaffold children's learning.

Angeli et al. (2016) draw upon various researchers’ definitions to provide an understanding of each element of CT:

Table 1 The elements of computational thinking (Angeli et al. 2016 pg.50)

Abstraction:	The skill to decide what information about an entity/object to keep and what to ignore (Wing, 2011).
Generalisation:	The skill to formulate a solution in generic terms so that it can be applied to different problems (Selby, 2014).
Decomposition:	The skill to break a complex problem into smaller parts that are easier to understand and solve (National Research Council, 2010; Wing, 2011).
Algorithmic thinking:	The skill to devise a step-by-step set of operations/actions of how to go about solving a problem (Selby, 2014).
Sequencing:	a) The skill to put actions in the correct sequence (Selby, 2014).
Flow of control:	b) The order in which instructions/actions are executed (Selby, 2014).
Debugging:	The skill to identify, remove, and fix errors (Selby, 2014).

Based on the five CT skills of abstraction, generalisation, decomposition, algorithmic thinking, and debugging, Angeli et al. (2016) developed a CT curriculum framework (Table 1) that includes indicators of competence for each CT skill. The framework sets out progression steps for each skill from simple to complex problem solving across the primary age range.

Table 2 Angeli et al. (2016) A computational thinking curriculum framework for K 6

Skill	Grade level (age range)		
	K-2 (age ranges 6 to 8)	3-4 (age 9 to 10)	5-6 (ages 11 to 12)
Abstraction	With the use of external reference systems, create a model/representation* to solve a problem (i.e., using specific directional language - forward, left turn, right turn, back - and turns of a given degree (90, 180, 270, 360), children create a path and write instructions to enable others to follow the path, or children design a mat-based on a story, and	Create a model/ representation to solve a problem (i.e., create an object and assign properties to it during an activity of digital game design and creation).	Create a new model /representation to solve a problem (i.e., create a simulation using Scratch).

	have their Bee-Bot follow the path from the narrative).		
Generalisation	Identify common patterns between older and newer problem-solving tasks and use sequences of instructions previously employed to solve a new problem (i.e., use a sequence of instructions from an older path, to program the Bee-Bot to follow a new path that includes the older path).	Remix and reuse (by extending if needed) resources that were previously created.	Remix and reuse (by extending if needed) resources that were previously created.
Decomposition	Break a complex task into a series of simpler subtasks (i.e., break a longer path into a series of smaller paths that the Bee-Bot can follow).	• Break a complex task into simpler subtasks. • Develop a solution by assembling together collections of smaller parts.	• Break a complex task into simpler subtasks. • Develop a solution by assembling together collections of smaller parts.
Algorithmic thinking	• Define a series of steps for a solution. • Put instructions in the correct sequence.	• Define a series of steps for a solution. • Put instructions in the correct sequence. • Repeat the sequence several times (iteration).	• Define a series of steps for a solution. • Put instructions in the correct sequence. • Repeat the sequence several times (iteration). • Make decisions based on conditions. • Store, retrieve, and update variables. • Formulate mathematical and logical expressions.
Debugging	• Recognise when instructions do not correspond to actions. • Remove and fix errors.	• Recognise when instructions do not correspond to actions. • Remove and fix errors.	• Recognise when instructions do not correspond to actions. • Remove and fix errors.
Note. *model/representation= can be conceptual, mathematical, mechanical, textual, graphical, etc.			

Bers (2020) through her work with KIBO robotics (Sullivan & Bers, 2015) and ScratchJr (Portelance et al., 2016), proposes seven CT skills as “powerful ideas” for early childhood computer science education. Papert previously coined the term “powerful ideas” to refer to a central concept and skill within a domain that is at once personally useful, epistemologically interconnected with other curricular areas, and has roots in intuitive knowledge that a child has internalised over a long period of time (Bers, 2020, p. 103). According to Papert, these powerful ideas offer new ways of thinking, new ways of using knowledge, and new ways of making personal and epistemological connections with other disciplines of knowledge (Papert, 2000). Bers (2020) outlines that powerful ideas in early childhood education should be adapted and defined in a developmentally appropriate manner for children from pre-school to the early years of primary. There must be continuum of development similar to the Angeli et al. (2016) model whereby algorithmic thinking in pre-school might be focused on simple linear sequencing and this would progress to repeating patterns or loops in older classes. (While the naming of these powerful ideas differs from Angeli et al. (2016) commonality is found in the definitions of the terms.) Bers (2020) outlines that powerful ideas in early childhood education should be adapted and defined in a developmentally appropriate manner for children from pre-school to the early years of primary. There must be continuum of development similar to the Angeli et al. (2016) model whereby algorithmic thinking in pre-school might be focused on simple linear sequencing and this would progress to repeating patterns or loops in older classes.

Table 3 Powerful ideas and early childhood education - Adapted from Bers (2020, p. 111)

Powerful ideas	Related Early Childhood Concepts and Skills
Algorithms	• Sequencing/order (foundational math and literacy skill) • Logical organisation
Modularity	• Breaking up a large job into smaller steps • Writing instructions • Grouping a list of instructions into a given category or module to complete a larger project
Control Structures	• Recognising patterns and repetition • Cause and effect
Representation	• Symbolic representation (i.e., letters represent sounds) • Models
Hardware/Software	• Understanding that “smart” objects don’t work by magic (i.e., cars, computers, tablets, etc.)
Design Process	• Problem-solving • Perseverance • Editing/revision (i.e., in writing)
Debugging	• Identifying problems (checking your work) • Problem-solving • Perseverance

From a constructionist perspective, CT can be thought about in much the same way as Papert viewed computer programming; that is, CT is both a skill to learn and a way to learn – *"to create, discover, and make sense of the world, with digital technologies as extensions and reflections of our minds."* (Cator et al., 2018, p.21). Papert's constructionist framework, states *"that children can learn deeply when they build their own meaningful projects in a community of learners and reflect carefully on the process"* (Bers, Seddighin, & Sullivan, 2013). Computational tools can be a powerful medium for creating contexts for constructing knowledge. However, in keeping with Papert's idea of engaging with "powerful representations," what is important to consider when designing a learning environment is not so much what programming language or computational materials to use, but what personally meaningful ideas the programming language and materials can enable the child to develop and how those ideas will develop CT and form new ideas about the subject area. This would indicate that CT should be developed in a technologically rich learning environment which offers children the opportunity not only to engage in critical thinking but also to be situated as the designer of their own projects (Bers, Ponte, Juelich, Viera, & Schenker, 2002). Activities and learning situations should be developmentally appropriate for the children and grounded in meaningful contexts.

3.4 Computational Thinking in the classroom

Constructionism acknowledges the importance of "objects-to-think-with" and creates a space for new technologies in the classroom. The use of objects-to-think-with has a long-standing tradition in the early childhood classroom. As previously mentioned in section 2.4.1, Montessori and Froebel designed a number of "manipulatives" or "gifts" to help children develop a deeper understanding of mathematical concepts such as number, size, and shape (Brosterman, 1997). In the 1960s, Papert began experimenting by adding computation to moving machines called "floor turtles". This gave children the option to control them with mechanical movement. These "floor turtles" were connected to a mainframe through cables. Children were able to programme the robot to perform different movements. In the modern-day classroom, Cuisenaire rods, pattern blocks, Lego, Digi Blocks, and other manipulatives have a commonplace in early childhood classrooms. All of these manipulatives have been designed with the child in mind to help them build and experiment. Mitchel Resnick and his colleagues in the Lifelong Kindergarten Group at MIT Media Laboratory have extended the idea of "digital manipulatives." These "digital manipulatives" such as programmable bricks and communicating beads expand the range of concepts that children can explore (Resnick et al., 1998). By embedding computational power within traditional children's toys such as balls, beads and blocks, children can learn about dynamic processes and "systems concepts," such as feedback and emergence that before were considered too advanced for this young age group (Resnick et al., 2000).

Research has shown that engaging children as young as four and five years old in developmentally appropriate robotics can engage children in learning programming concepts and skills used in computer science (Bers et al., 2014; Sullivan et al.,2013). Robotics is an effective way to introduce computational skills as children are engaged with processing tasks and developing a step-by-step code needed to program a robot. Bers (2008) outlines that robotics manipulatives enable children to use their hands to develop fine motor skills, hand-eye coordination and to engage in collaboration and teamwork. They do this by bringing abstract ideas to the classroom in a concrete and tangible way.

Chalmers (2018) highlights limitations within previous studies on robotics and CT as most studies have focused on the children while only a small number of studies have focused on teachers and their integration of robotics and CT skills in the primary classroom. When reviewing how CT skills have been taught during the last decade, the research community has welcomed educational robotics as an approach for teaching CT to pre-primary education children (Alimisis & Kynigos, 2009; Benitti, 2012; Bers, 2010; Bers et al., 2014; Botički et al., 2018; Bredenfeld, Hofmann, & Steinbauer, 2010; Johnson, 2003; Kazakoff, Sullivan, & Bers, 2013; Stoeckelmayr et al., 2011). Teachers have used educational robotics in order to engage young children in active and playful learning activities through programming tangible robotic devices (Bers, 2010). Recent research studies investigate how educational robotics is an appealing approach for developing young children's CT skills because children can directly interact with a robot and observe the immediate feedback of their actions on the robot's behaviour (Beraza, Pina, & Demo, 2010; Bers, 2010; Bers et al., 2014; Highfield, 2010; Highfield & Mulligan, 2008, 2009; Kazakoff & Bers,2012; Stoeckelmayr, Tesar, & Hofmann, 2011).

In particular, research by Bers and her colleagues (Bers et al., 2014; Kazakoff & Bers, 2012; Sullivan & Bers, 2016) showed that children as young as four years old were able to engage in CT skills activities using a robotics curriculum. Other researchers, such as Beraza et al. (2010), Stoeckelmayr et al. (2011), Highfield (2010), Highfield and Mulligan (2008), used the programmable floor robot, Bee-Bot, for promoting pre-primary children's CT. The limited programming power of the Bee-Bot makes it an ideal first robotic tool to use with young children because young children can quickly learn how to program it and engage in rich CT activities with it by touching it and directly interacting with it (Highfield & Mulligan, 2008). In addition, according to Kabátová, Jašková, Lecký, and Laššáková (2012), learning how to program with the Bee-Bot first can facilitate young children's CT activities with more advanced programming languages in the future. A review of the literature from Angeli and Valanides (2020) highlights three main areas:

a) exploring children's interactions with the tools within the context of various content domains, such as math, science, literacy, and engineering (Highfield, 2010; Highfield & Mulligan, 2008; Lavigne & Wolsky, 2018),
b) investigating ways in which educational robotics can afford learning opportunities to educate young children (Highfield & Mulligan, 2008; (Kabátová et al., 2012), and
c) familiarising children with robotics concepts and computer programming (Misirli & Komis, 2014; Selby, 2012; Stoeckelmayr et al., 2011).

These efforts are noted as worthwhile in terms of taking steps toward investigating the uses of educational robotics in the development of young children's CT; however, they do not:

a) provide robust empirical evidence of learning gains in computational thinking,
b) describe how teachers scaffolded young children' computational thinking,
c) provide detailed information about how young children's computational thinking skills were assessed, and
d) address gender differences in computational thinking between boys and girls

(Angeli & Valanides, 2020).

Robotics has also been established through empirical research as a way for children to develop fine motor skills and hand-eye coordination as they work together in groups. Robotics provides a playful way for teachers to integrate curriculum content with the development of meaningful projects (Bers et al., 2013). While using robotics, children are given the opportunity to experiment with engineering concepts as well as telling stories by narrating contexts for their projects (Bers, 2008b). By engaging in these types of robotics projects, *young children play to learn while learning to play in a creative context* (Bers et al., 2013; Resnick, 2003).

3.5 Linking the stages of Coding with Literacy

This research investigates the language and computational skill development through the use of robotics and aims to explore a potential link between both areas of development. Some research has begun in this area linking literacy strategies and coding together. Bers (2020) in a recent publication “Coding as a Playground”, draws a comparison between coding and language learning, suggesting that coding is another language, a literacy that should be taught in all early year's classrooms. Reflecting on the social interactionist perspective to language learning, children learn a language to engage with each other, and by communicating, they are learning a linguistic code that includes syntax and grammar (Bruner 1975, 1985). While children are learning about language, they are also using it at the same time. There is flow over and back within this process, and it is difficult to pinpoint which comes first as there is significant scaffolding available at this stage of development through adults during home activities, peers and in the classroom. Bers suggests that coding is similar, that children can learn to code and use it to create their own projects and share their own interests. Through using language or the code, the child develops fluency. Similar to literacy, “coding involves doing, creating, and making, not just thinking” (Bers, 2020, p. 63). In early childhood education, there are coding languages that represent computation instructions, and these languages are used to create and play by combining computational instructions in new ways. As children move on from a basic coding language, they begin “playing with grammatical rules and discovering new syntax.” With CT and coding becoming more valued for the workforce of the future, Bers asks, *“will computational literacy become the new literacy of the twenty-first century?”*

When teaching early childhood literacy, it is essential to adhere to developmentally appropriate practice as outlined by Bredekamp (1987) and consider the diverse stages of children's learning through pedagogies such as play and discovery, socialisation, and creativity (Bers, 2018a). A pedagogical approach for early childhood computer science called "Coding as Another Language" (CAL) has been developed by Bers. This approach is rooted in the core principle that learning to program involves acquiring proficiency in a new language, serving communicative and expressive functions. Bers (2019) identifies six distinct coding stages that young children progress through when learning to code using this approach. These stages are compared with the stages of literacy instruction and coding described by Chall (1983) and other researchers (Ryan, 2011; Clarke et al., 2015). Furthermore, Bers highlights that the coding activity's learning progression was influenced by Piaget's stages of progression (1952).

The coding stages introduced by Bers (2019) depart from the rigid framework of Piaget's stages and instead aim to construct a comprehensive model to describe the learning trajectory of young children. This model is designed to be supported through instructional methods and encompasses a curriculum, a programming language (e.g., KIBO robotics and/or ScratchJr), and a pedagogical approach known as the Positive Technological Development Framework (Bers, 2012). The six coding stages are derived from extensive behavioural observations and data collected over a period of more than two decades, involving young children aged 4 to 7 who were learning to code in various settings using diverse integrated CAL-based curricula. In CAL, the act of coding is situated as a meaning-making endeavour, surpassing its role merely as a problem-solving challenge. Throughout all six coding stages, the teaching process involves encouraging children to utilise the programming language to conceive and share a personally meaningful project (Bers, 2019).

The PTDF, guides the development, implementation and evaluation of curriculums that use new technologies. According to Bers (2012) from a theoretical perspective, PTDF promotes an interdisciplinary approach that integrates different parts of computer-mediated communication, computer-supported collaborative learning, and the Constructionist theory of learning. The PTDF proposes six positive behaviours (six C’s): content creation, creativity, communication, collaboration, community building and choices of conduct. The six C’s of the PTDF are divided between supporting intrapersonal behaviours (content creation, creativity, and choices of conduct) and interpersonal behaviours (communication, collaboration, and community building).

The development of CAL was influenced by the work of Papert and research from literacy instruction. Linking to Constructionism, which was previously outlined in section 3.1, Bers (2019) reflects that when children are given the opportunity to learn a programming language to create computational projects for expression, they are likely to encounter “powerful ideas” from different subject areas and then reflect on their own thinking (Bers, 2019, Papert 1980; Bers 2008; Resnick 2017; Kafai and Resnick 1996). CAL outlines how the strategies used in the classroom for teaching alphabetical literacy (natural language) can be used to teach coding literacy (artificial language).

Languages are symbolic representational systems, with grammar and syntax that can be used to convey meaning and to produce something new. Therefore, the end goal of the activity of coding and decoding is to ultimately comprehend, generate, communicate, and express ideas or thoughts by making a shareable product that others can interpret (Bers, 2018a). Within this perspective, CAL puts problem solving at the centre of personal expression. CAL’s approach and curriculum explore the parallels between programming and natural languages and their communicative and expressive functions. As outlined previously in chapter two, research shows that children mediate their learning with and through language (Vygotsky, 1978). Therefore, by learning to use a programming language that involves logical sequencing, abstraction, and problem-solving, children can learn how to think in analytical ways. Mitchel Resnick and David

Siegel, when discussing the creation of the Scratch Foundation, promote an expressive approach to coding,

> *"For us, coding is not a set of technical skills but a new type of literacy and personal expression, valuable for everyone, much like learning to write. We see coding as a new way for people to organize, express, and share their ideas … In many introductory coding activities, students are asked to program the movements of a virtual character navigating through a set of obstacles toward a goal. This approach can help students learn some basic coding concepts, but it doesn't allow them to express themselves creatively — or develop a long-term engagement with coding. It's like offering a writing class that teaches only grammar and punctuation without providing students a chance to write their own stories"*
>
> *(*Resnick & Siegel, 2015, pg. 1-4*)*

Papert reminds us that children are not only likely to learn how to program but also to encounter knowledge from other areas (Papert, 1980). The CAL curriculum puts computer science in direct conversation with powerful ideas from literacy identified by Chall (1983) and other literacy researchers (e.g., Shanahan et al., (2010); Duke and Pearson (2002). The process of learning how to program expressively takes time and requires instruction. While children can discover things on their own, a curriculum shows a pathway to expose them to a comprehensive scope and sequence. However, the curriculum must be rooted in stages of learning and developmental models of how children think and operate within a domain (Clements 2007; Clements and Sarama 2004).

3.6 Conclusion

This chapter delves into Seymour Papert's constructionism theory, highlighting its relevance in fostering computational thinking (CT) skills and the use of tangible manipulatives to promote CT in the classroom. It also explores the diverse definitions of CT skills and their integration into the primary school curriculum. The section on robotics emphasises the practicality of employing "objects-to-think-with" for hands-on learning, particularly for young children, as they construct knowledge through tangible materials. Robotics, in this context, offers a real-life application for knowledge construction.

Extensive research evidence supports the effectiveness of robotics as a valuable tool for introducing computational skills and coding in early childhood education. Notably, Section 3.5 discusses the shift from the conventional focus on using robotics solely for numeracy skills, exploring its potential integration into other areas of the curriculum.

Additionally, Section 3.6 critically reviews recent developments in the CAL curriculum, drawing connections between learning to read and write and learning to code through the six coding stages. This linkage establishes a compelling argument for the interconnectedness of coding and language learning, reinforcing the idea that coding can significantly contribute to language development.

The next chapter will examine the methodology and design of a research investigation utilising programmable floor robots to promote second language learning in the early years of primary education through a playful approach. Chapter 4 will provide detailed research questions, an outline of the methodological approach, and a robust data analysis to strengthen the evidence and support the claim that coding can indeed be effectively linked to language learning.

4 Design of the research

Chapter 2 and 3 explored the three main elements of literature applicable to this study: SCT and its constructs; second language learning and language development in the early childhood education; and CT skills development using robotics. This chapter will outline of the research activity, technological considerations, and key aspects to the data analysis. The research questions and an overview of the study are presented in section 4.2. Section 4.5 explores the mixed methods approach of quantitative and qualitative are described in section 4.6. Next, the methodological approach describes Design Based Research (DBR) and alternative approaches considered for this research. Following this the research instruments and data analysis are described. Section 4.10 looks at ethical considerations and child assent during the research intervention. Finally Section 4.11 looks at the limitations of the study.

4.1 Research questions

The aim of this study is to investigate the use of programmable floor robots for second language learning and developing CT skills in the early years of primary school. More specifically, this study aims to explore the correlation between CT skills development and language learning during play through the following research questions:

1. What are children's attitudes towards using robotics for second language learning?
2. What evidence of language learning can be observed during a robotics-based intervention and what are the processes that support this learning?
3. What evidence of the development of computational thinking skills can be observed during a robotics intervention and what are the processes that support this learning?

4.2 Overview of Study

The research presented in this thesis was complex and involved several iterations drawing on a number of approaches. For clarity on the complexity of the study, an overview of the research and design process is presented in this section prior to looking at the individual elements of the design, development, and each research cycle.

- A design-based research methodology was used. This process allowed for the iterative design of the activity while maintaining a focus on the participant's feedback (teacher and children) and ensuring an emphasis on the research literature. This methodology was used through a series of iterative cycles, which incorporated the participant's feedback and contributed to theory formation while optimising the design of the activity for all participants.

- The iterative design cycle had four iterations. Three pilot cycles and one main cycle, cycle four which took place over six weeks. The children participated in their language lesson, and the robotics activity was used during play session or activity time, to further their language development and CT skills. This activity was the basis for responding to the research questions.
- A mixed-methods approach was taken for data collection and analysis, with activity recordings and focus groups offering a detailed source of qualitative data and questionnaires comprising the quantitative data.
- To ensure that the children's views were integrated as part of the study, a child voice methodology was selected as the most appropriate to guide and direct the consultation process, this was supported through questionnaires and focus groups with the children.

An overview of the study may be seen in table 3 and 4. The findings from each cycle and the user consultation were instrumental in developing and adapting the activity for cycle four. Cycle four is the focus of this thesis as it was developed on the feedback from the three pilot cycles and the research questions outlined in 4.2 were addressed by this cycle.

Table 4 Overview of pilot cycles 1 and 2

	Pilot cycle one (1 day)	Pilot cycle two (1 day)
Details	• Language lesson taught by the teacher • Small group activities (free writing table, sand, constructions etc.) focused on language lesson one to the robotics activity • Children move from one activity to the next. Each activity is 15 minutes in duration with five intervening minutes to change groups • Children will be recorded at the robotics activity • 150 minutes • 27 participants, Boys, Senior Infants	• Language lesson taught by the teacher • Small group activities (free writing table, sand, constructions etc.) focused on language lesson one to the robotics activity • Children move from one activity to the next. Each activity is 15 minutes in duration with five intervening minutes to change groups • Children will be recorded at the robotics activity • 150 minutes • 21 participants, Girls, Senior Infants
Overview	The children will participate in a robotics activity during Play with a focus on the target from their Irish language lesson.	The children will participate in a robotics activity during Play with a focus on the target from their Irish language lesson.
Objectives	The goal of this cycle was • Test assent form, questionnaires, and data collection tools • Gather feedback from the children and the teacher on the design of the activity.	The goal of this cycle was • Test the design of the activity, focus group model and data collection tools • Gather feedback from the children and the teacher on the design of the activity.
Research design	• Exploratory pilot	• Exploratory pilot rectifying any issues that arose in pilot cycle one
Data collection	• Pre- and post-intervention questionnaire • Video recordings • Children's focus group • Teacher interview	• Pre- and post-intervention questionnaire • Video recordings • Children's focus group • Teacher interview

Table 5 Overview of pilot cycles 3 and cycle 4

	Pilot cycle three (6 weeks)	Cycle four: main study (6 weeks)
Details	• Language lesson taught by the teacher • Small group activities (free writing table, sand, constructions etc.) focused on language lesson one to the robotics activity • Children move daily from one activity to the next. Each activity is 20 minutes in duration • Children will be recorded at the robotics activity • Participants (Senior Infants, 24, Co-educational)	• Language lesson taught by the teacher • Small group activities (free writing table, sand, constructions etc.) focused on language lesson one to be robotics activity • Children move daily from one activity to the next. Each activity is 20 minutes in duration (6 weeks x 4 recordings per week, 1 group did not have consent) • Children will be recorded at the robotics activity • Participants (Junior Infants, 27, Co-educational)
Overview	The children will participate in a robotics activity during Play with a focus on target from their Irish language lesson	The children will participate in a robotics activity during Play with a focus on target from their Irish language lesson
Objectives	The goal of this cycle was • Run the activity • Gather feedback from the children and the teacher on the design of the activity. • Investigate the teacher's participation in the design process and dynamic response to the activity.	The goal of this cycle was • Run the activity • Gather feedback from the children and the teacher on the design of the activity. • Address the research questions of the study. • Teachers' role in the implementation of the activity
Research design	• Exploratory study • Focus on the child's motivation during activity • Focus on the child's perceived enjoyment of the activity • Focus on the target language used during the activity.	• Exploratory study • Focus on the child's motivation during activity • Focus on the child's perceived enjoyment of the activity • Focus on the target language used during the activity.
Data collection	• Pre- and post-intervention questionnaire • Video recordings • Photographs • Children's focus group • Teacher interview • Teacher's reflective journal • Children's drawings	• Pre- and post-intervention questionnaire • Language assessments • Video recordings • Photographs • Children's focus group • Teacher interview • Teacher's reflective journal • Children's drawings

This research project involved designing and running a playful learning intervention that used programmable floor robot during a play session for second language learning and CT skills development. Four cycles of this Design-Based research (DBR) project ran over eight months: two initial pilot cycles of one day each, and a third pilot cycle of six weeksand a fourth more developed intervention of six weeks. The activity aligns with the Irish language lesson taught each day by the teacher. Along with the teacher's views the children's views on activities for language learning, technology for language learning and Irish language learning in junior and senior infants informed each of the cycles. A questionnaire was distributed amongst the children before and after each cycle (signpost child voice) and focused on their interest in learning Irish (signpost), to use Irish and – if they use technology – to learn. During the intervention, a structured area for the programmable floor robot activity was established in the classroom, and each day (over cycle four), a different group of children participated in the robot activity while being supervised by their teacher. The images and words on the floor mat that the robot traversed focused on language from their Irish lesson.

Data was gathered from each cycle, with the following list of data collected during cycle four:

1. Video recordings of children's engagement and conversation with their classmates while using the robots
2. Photos of the activity taken by the classroom teacher and researcher
3. Teacher's reflective diary: where general observations of the children's engagement with the activity are recorded. The participating teacher was encouraged to reflect on any changes in the use of language, attitude towards the language and developing proficiency in the coding of the robot. The teachers in cycles three and four were encouraged to do this as there was more of an opportunity to recognise these changes. During the pilot cycles, the researcher recorded their observations and sought insight from the teacher during their post-intervention interview
4. A focus group took place with the children after the second and third pilot cycles and at the end of cycle four. The researcher explored the children's perspectives and opinions about the activity
5. A questionnaire before and after the activity was distributed amongst the class, and any further verbal contributions from the children were noted

6. An audio-recorded interview was conducted with the teachers from pilot cycles one and three and the main cycle, cycle four. Ongoing consultation took place between the researcher and the teacher over pilot cycle three and cycle four due duration of the cycle and the nature of the design-based research method.

4.2.1 Learning Outcomes

As previously mentioned, the research intervention followed the Primary Language Curriculum (PLC) learning outcomes (LOs) (Section 2.2.2). Learning Outcomes are described as “the expected learning and development for learners at the end of a period of time” (Government of Ireland, 2019). The curriculum acknowledges that children’s progress towards Learning Outcomes will be influenced by their varying circumstances, experiences and abilities. By focusing on learners, outcomes enable teachers to use a range of appropriate pedagogical approaches to support children on their learning journey. In the early years of the primary school (Junior and Senior Infants) all LOs begin with ‘Through appropriately playful learning experiences, children should be able to...’ (Government of Ireland, 2019). The learning outcomes the classroom teacher followed for their Irish language lesson were also used during the play session to encourage integration and consistency between activities.

The PLC outlines 12 LOs for Teanga ó Bhéal/Oral Language for Irish and English. The main learning outcomes explored during the play session are listed in Irish and an English translation in Table 2.

Table 6 Language Learning Outcomes

Toradh Foghlama 1 **Learning Outcome 1**	**Rannphháirtíocht, éisteacht agus aird** Spéis agus comhaird a léiriú agus éisteacht go gníomhach le Gaeilge shaibhir á labhairt i réimse comhthéacsanna ar mhaithe le spraoi, cé nach gá go dtuigfeadh siad gach focal.	**Engagement, listening and attention** Demonstrate interest and joint attention and listen actively to very fluent Irish being spoken in a variety of contexts for fun, although it need not be the case that they understand every word.
Toradh Foghlama 3 **Learning Outcome 3**	**Gnásanna sóisialta agus feasacht ar dhaoine eile** Feidhmiú mar chuid de ghrúpa agus roinnt focail/frásaí Gaeilge á núsáid	**Social conventions and awareness of others** Function as part of a group using some Irish words/phrases.
Toradh Foghlama 5 **Learning Outcome 5**	**Stór focal** Éisteacht le cainteoir agus leideanna éagsúla ar nós geáitsí, fíorábhar, nó	**Vocabulary** Listen to a speaker and use various clues such as gestures, supporting items, or intonation to decipher the

	tuin chainte a úsáid chun teacht ar an bpríomhtheachtaireacht. Úsáid a bhaint, le linn spraoi agus comhrá as roinnt focail/frásaí Gaeilge bunúsacha a chloiseann siad go minic.	main message, and reach an understanding that communication can take place in different languages. Make use, during play and conversation, of some basic Irish words/phrases that they often hear.

4.2.2 Prior learning

The participants involved in Cycle 4 of the study were in Junior Infants, as detailed in Table 5. Prior to the research intervention, these participants had experienced approximately three months of Irish language lessons. This instructional period encompassed a range of thematic areas, including "Is mise" (self-introduction); "Ar scoil" (school-related concepts); "An bosca lóin" (the lunchbox); "Ag súgradh" (Play); "An bosca éadaigh" (The clothes box); "An Tornapa Mór" (The Giant Turnip, a traditional story); "Oíche Shamhna" (Hallowe'en); "Cén sórt aimsire atá ann?" (Exploring weather); "An teach" (The house); and "Sa siopa bréagán" (In the toy shop).

Each of these thematic units entailed a curated set of target language, which were systematically taught during the Irish language lessons. The target language used in the research intervention for this phase followed a similar structure as outlined in Appendix J.

4.3 Bee-Bot

There are a number of educational robotics resources available that introduce programming in the early years (Muñoz-Repiso & Caballero-González, 2019). The use of robotics in education – such as a Lego WeDo, KIBO and Bee-Bot – find their origins in the work that Papert and the LOGO turtle, which was presented in chapter 3. The programmable floor robot that was used for this study is Bee-Bot. Bee-Bot is a programmable floor robot that looks like a bee. The TTS Group designed this robot for programming in the early years. The Bee-Bot is a programmable floor robot that children can touch, hold, and interact with using six directional keys (Misirli & Komis, 2014). Hamilton et al. (2019) categorises the Bee-Bot as a 'Button-Operated Robot'. Bee-Bot is both resilient and appealing in design, while its compact size enables effortless handling by young children. (Muñoz-Repiso & Caballero-González, 2019). Its colours, sounds, and movements make it a suitable resource for use with young children between the ages of 3 and 7 (Muñoz-Repiso & Caballero-González, 2019).

There is no computer programming or computer involved during learning with the Bee-Bot. Learning materials using the Bee-Bot include motivating problem-solving scenarios that the teacher has to develop and a variety of mats, which provide great surfaces for the Bee-Bot to move on. Bee-Bot can move forward and backwards 15cm, turn at a 90-degree angle and pause. Bee-Bot can also memorise up to 40 steps. The 2019 version of Bee-Bot can memorise up to 200 steps which allows a child to create a more complex sequence or program (Muñoz-Repiso & Caballero-González, 2019). Bee-Bot blinks and beeps at the conclusion of each command to allow children to follow Bee-Bot through the program they have entered and then confirms its completion with flashing lights and sound.

Playing with Bee-Bot, inputting commands by pressing the buttons and simply engaging with the device are examples of children familiarising themselves with digital devices, developing their understandings of robots, and learning how to code or the literacy practices of coding (Walsh & Campbell, 2018). While the Bee-Bot is an easy-to-use tool with young children, at the same time, it is important that teachers learn how to use it in an appropriate pedagogical way so they can maximise its effects on the development of young children's CT skills. As it is well documented in the literature, scaffolding children during learning with educational technology tools is important (Burke & Kafai, 2012; Fesakis, Dimitracopoulou, & Palaiodimos, 2013; Klein, Nir-Gal, & Darom, 2000; Mercer & Fisher, 1992; Shute & Miksad, 1997).

Figure 5 Bee-Bot (*Cycle 4)

Walsh and Campbell (2018) highlight that learning to code a Bee-Bot also has some disadvantages. As the researchers note, without first manipulating 'code you can touch,' it can be difficult for young children because it is too abstract. The children cannot 'see' the code once they have pushed the buttons on top of the Bee-Bot. They also cannot watch the Bee-Bot execute the coded sequence they entered alongside the symbols, nor understand how their coding was entered incorrectly if the Bee-Bot does not go where they wanted it to go (Walsh & Campbell, 2018).

The Bee-Bot used during the main cycle of this study can also record audio that can be assigned to each direction it takes. The recording plays back when each button is pressed so that the children can hear the commands, they have given the robot as he moves. (As this is a new feature to Bee-Bot in 2019, it was only available in the Bee-Bot used for cycle four.) In cycle four, a recording of a direction was linked to each button. As the children pressed the button with the arrow forward, they hear the word in Irish word for forward (ar aghaidh). As Bee-Bot executed the code, it would play the word linked to each move. Bee-Bot moved around on a floor mat that was designed by the researcher and the classroom teacher initially and later designed by the children. The mat displayed pictures and words that the children were aware of from their Irish language lesson. One mat was created for each of the pilot cycles after discussing the language lesson with the teacher and, during pilot cycle three and cycle four, the mat was changed fortnightly in line with the topics and target language that the teacher was delivering during the language lesson.

4.4 SCT and DBR

When conducting research involving young children, the combination of Design-based Research (DBR) and Sociocultural Theory (SCT) can create a powerful methodology. DBR integrates theory and practice to design, implement, and evaluate educational interventions in real-world settings, while SCT emphasises the influence of culture and social interaction on learning and development. By combining these approaches, researchers can create an iterative process that considers the sociocultural context of learners.

In a study with young children, DBR provides a structured approach to developing, testing, and refining interventions. It begins with a needs assessment to identify challenges specific to the sociocultural context of the children. Using SCT principles, such as valuing social interaction and cultural practices in learning, an intervention is designed accordingly. This intervention is then implemented in a real-world setting, with continuous data collection and evaluation to measure its impact. SCT informs the design phase by emphasising the importance of cultural practices and social norms. For instance, activities in a study involving children from a particular cultural group may incorporate traditional practices or values. The intervention can also promote social interaction through collaborative learning or peer mentoring.

This research intervention followed an iterative process Design-Based Research (DBR), which allowed for continuous refinement of the intervention based on the data collected. Social Cognitive Theory (SCT) played a vital role in the evaluation process by considering the sociocultural context in which the intervention took place. The data obtained from the evaluation analysis informed modifications to better align the intervention with the learners' sociocultural context. This iterative approach continued until a successful intervention was developed. The study aimed to examine the effectiveness of using a robotics tool to promote second language learning in a classroom setting with young children. Since the participants had already been learning Irish for four months, with daily language lessons lasting 20-25 minutes, conducting a language assessment before the intervention was considered inappropriate. Additionally, the target language they would encounter during the intervention was entirely new to them, making pre-assessment unfeasible.
The research intervention focused on designing a playful activity using Bee-Bot to encourage the children's use of the target language they learned in their Irish lessons during a storytelling play session. The objective was not to achieve language fluency from the children at this stage of their language learning journey but rather to observe and analyse their increased use of the target language over time. One of the research goals was to investigate the socio-cultural constructs that supported the implementation of this activity. Pilot studies were conducted to test and refine the intervention's design, and the evidence of socio-cultural constructs was thoroughly analysed throughout the process. Through this approach, the researcher aimed to develop an intervention that would effectively enhance second language learning in the given sociocultural context.

The integration of DBR and SCT in research with young children offers a systematic and iterative approach to developing interventions that are culturally responsive. By considering the sociocultural context, these interventions can effectively enhance learning and developmental outcomes for young children.

4.5 Mixed methods

The terms method and methodology are often confused and used interchangeably. However, there are significant differences between the two. For example, the latter consists of a general approach adapted to carry out the research (design-based research), and the former refers to varied tools used to gather data (focus groups, interviews, video recordings, questionnaires etc.) (Cohen, Manion, & Morrison, 2018). This section focuses on the qualitative and quantitative methods or tools used to investigate participants' perspectives on the use of robots for language learning and computational skill development during play. The methodology selected for this study was mixed methods approach incorporating quantitative research, which includes questionnaires and an in-depth look at skill development, as well as qualitative research of video recordings and focus groups, which offered a detailed source of data for this study. Through this mixed-methods approach, the study considers the multiple viewpoints, perspectives, positions, and standpoints from the children, the teacher, the researcher, and the literature. Even though it has only been well established since the 1990s, mixed methods may be defined as:

> *An intellectual and practical synthesis based on qualitative and quantitative research; it is the third methodological or research paradigm (along with qualitative and quantitative research). It recognizes the importance of traditional quantitative and qualitative research but also offers a powerful third paradigm choice that often will provide the most informative, complete, balanced, and useful research results*.
> (Johnson, Onwuegbuzie, & Turner, 2007, pg. 129).

4.5.1 The rationale for a mixed-methods approach

The choice of a mixed-method approach for this research was influenced by the specific context in which the study was conducted. Quantitative data was necessary to include the children's voice and ensure that they were active and informed participants in the study. This quantitative data gathered aimed to provide insights into the children's attitudes towards Irish, their language usage, and their enjoyment of using technology for language development. This information informed the discussion on research question one. The age of the research participants posed some limitations to the quantitative research component, which is further explored in section 4.6.4 and 4.11.

To gain deeper insights into the research questions, qualitative data played a crucial role. Research questions 2 and 3 specifically addressed the language learning process, computational thinking development, and the sociocultural environment that facilitates these learning processes. Focus groups and input from the teacher helped to contextualise and interpret the findings from the quantitative data collection. Given that the study involved early primary school children, a qualitative dominant mixed-methods approach was deemed more appropriate, as observation and focus groups can yield valuable insights (Johnson & Onwuegbuzie, 2004). This approach aligns with the definition provided by Johnson et al. (2007), where "the type of mixed research in which one relies on a qualitative, constructivist-poststructuralist-critical view of the research process, while concurrently recognising that the addition of quantitative data and approaches are likely to benefit most research projects".

The mixed-methods approach allowed for comprehensive answers to each research question. Brown (2011) emphasises the strength of combining qualitative and quantitative methods, as they reinforce and cross-validate each other. Dörnyei (2007) highlights the complementary nature of a mixed-methods approach, which allows for potential multi-level analysis and validation through triangulation, defined as the combination of methodologies in studying the same phenomenon (Denzin, 2009, p.291). Additionally, the mixed-methods approach compensates for the limitations of using either a quantitative or qualitative approach in isolation. In this study, the depth and richness of the qualitative data from video recordings and focus groups compensate for the limited quantitative data collected.

4.5.2 Quantitative research

According to Dörnyei (2007), quantitative research is interested in the variables rather than cases; the use of statistics is concerned with the standardised procedures to assess objective reality and seeks generalisability of results (Dörnyei, 2007, pp. 33-34). Brown (2011) goes further to categorise quantitative research into four types: descriptive, exploratory, quasi-experimental, and experimental. Brown highlights that these are not mutually exclusive categories, and studies can fall into one, two or three of them. This study will fall into the descriptive category outlined by J. D. Brown (2011) *"as those that describe behaviours, outcomes, scores"*. As one of the major types of data analysis, descriptive analysis is popular for its ability to generate accessible insights from otherwise uninterpretable data. Unlike other types of data analysis, descriptive analysis does not attempt to make predictions about the future. Instead, it draws insights solely from past data by manipulating it in ways that make it more meaningful. Descriptive analysis is all about trying to describe or summarise data. Another benefit of descriptive analysis is that it can help to filter out less meaningful data. This is because the statistical techniques used within this type of analysis usually focus on the patterns in data and not the outliers.

4.5.3 Qualitative research

There is a wide range of methods and approaches to qualitative research. "Qualitative research is many things to many different people" (Denzin and Lincoln, 2005). Qualitative researchers do not necessarily set up experimental conditions in which to carry out their studies, but rather they aim to capture and interpret what happens naturally in the classroom (Dalton, 2017). Some key features describe the core of a qualitative approach. The principal characteristic, according to Dörnyei (2007), is that the research design is usually flexible. Qualitative researchers are free to respond to whatever emerges from the process. These research designs are not rigid and are open to adaptation and change. This approach is applicable in the context of this study, researching with young children. Working with young children in the classroom environment cannot be rigid as it is a natural environment that can change quickly depending on the school and classroom schedule and indeed the needs of the children. Gathering qualitative data in the classroom can involve several different types of data such as text, images, and interviews to capture the experiences of an individual in their environment. "Qualitative data consists of records of phenomena which deal with the qualities or characteristics of those phenomena, rather than the measurements, frequencies, scores, or ratings" (Bailey & Nunan, 1996, p. 2). This study will capture data during the play activities time slot during the school day where small groups of children play at different activity stations.

4.6 Methodological Approach

Within the framework of a mixed-methods approach, a Design-Based Research (DBR) paradigm was chosen. The ecological theoretical basis for this investigative research project required a methodological approach that could deal with the complex learning environment, the integration of a robotics tool and the use of a number of data sources to answer specific research questions. Due to the nature of the study whereby the daily activity was reviewed at the end of the week, extended, and perhaps amended, the most effective approach was a collaboration between the researcher and the teacher. DBR provided a robust framework for technology design and educational research. It extends to multiple perspectives and data sources that integrate design and research processes. This approach will be outlined further in the next section, along with the child voice methodology, which will be used for consultation with the research participants.

4.6.1 Design-Based Research

DBR within this study involves collaboration with four teachers on the development of the questionnaire, the activity, and reviewing of data and the design of the activity. The classroom teachers were members of the research team during the DBR cycle and played a crucial role in collaborating with the researcher in amending the activities and developing resources alongside the researcher. This presented a logistical challenge for the researcher as it involved maintaining a productive collaborative partnership with the classroom teacher in the research context, the classroom (Design-Based Research Collective, 2003). DBR offered multiple variables within this process (Wang and Hannafin, 2005). DBR offered multiple variables within this process. Wang and Hannafin (2005) describe it as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually sensitive design principles and theories" (Wang & Hannafin, 2005, pp. 6-7). DBR allows flexibility for the incorporation of many perspectives in a feedback loop, which links to further cycle development. This iterative design cycle was crucial for this study when developing the activity with the classroom teacher, refining it, and implementing it as a daily classroom activity. Wang and Hannafin's (2005) principles of analysis, outlined in Figure 4 below, played a vital role in the continuous refinement of the activity through the cycles. These principles of analysis acted as a guide to the researcher while moving through the DBR process with the teacher as a collaborator. Wang and Hannafin (2005) identify nine key principles that are important to the planning and implementation of a technology-enhanced learning environment:

Table 7 Wang and Hannafin, 2005 - Principles of analysis

Principle 1	Support design with research from the outset
Principle 2	Set practical goals for theory development and develop an initial plan
Principle 3	Conduct research in representative real-world settings
Principle 4	Collaborate closely with participants
Principle 5	Implement research methods systematically and purposefully
Principle 6	Analyse data immediately, continuously, and retrospectively
Principle 7	Refine design continually
Principle 8	Document the contextual influences with design principles
Principle 9	Validate the generalisability of the design

Design-Based Research (DBR) has undergone development and evolution in line with the principles of an ecological paradigm. The DBR Collective (2003) defines DBR as a methodology that combines empirical educational research with the theory-driven design of learning environments. This approach is crucial for gaining insights into the functioning and effectiveness of educational innovations in real-world contexts, including understanding the factors of how, when, and why they work in practice. The roots of the current DBR approach can be traced back to Collins' work in the 1990s.

The emergence of the current Design-Based Research (DBR) approach can be traced back to the 1990s when Collins (1992) and Brown (1992) introduced the concept of "design experiments." These pioneering efforts marked a shift towards an ecological and situational approach to studying and optimising learning. Collins and Brown recognised that many of the questions they sought to address could not be adequately answered through laboratory-based experiments alone (Barab & Squire, 2004, p. 12).

Over the past 25 years, DBR has gained popularity as a methodological approach, allowing researchers to move beyond the confines of the laboratory and explore learning in real-world contextual environments. This approach has enabled the study of existing theories and the development of new ones, providing researchers with valuable insights. The growth of DBR has been driven by its potential to bridge the gap between theory and practice, offering opportunities to improve educational practices within the classroom (Anderson & Shattuck, 2012).

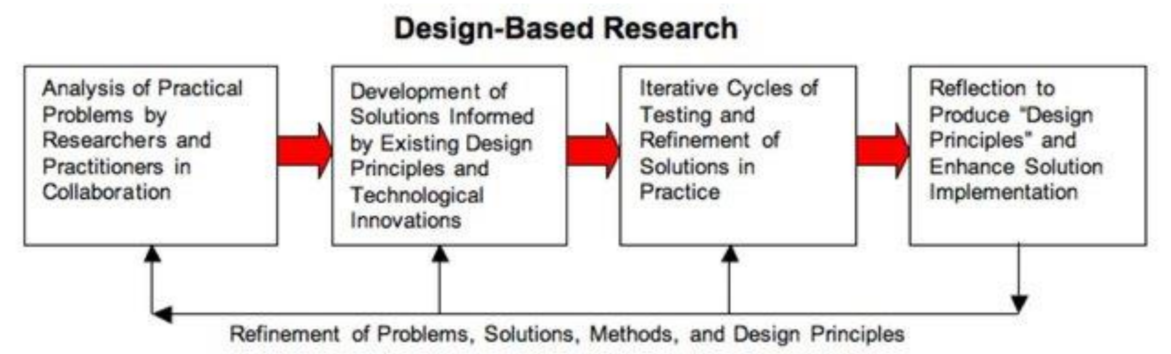


Figure 6 Amiel and Reeves - Design-Based Research

Amiel and Reeves (2008) illustration of the DBR shows how researchers and teachers can work together in an iterative design cycle. The co-operation between both parties is essential to the DBR process as both parties work together to identify problems with the intervention and design possible solutions driven by theory and experience. This collaborative process was realised in this study as the researcher worked with the classroom teachers during each cycle to test the floor-programmable robot and how it might impact language learning and CT skills development. The lessons learned from the iterative process contribute to design principles and theory itself so that it can be reproduced in other classrooms and applied in a wider context. Wang and Hannafin (2005) outline the central characteristics of DBR in Table 5 below. There is a cross over between the characteristics of DBR and ecological paradigm for language learning as described in chapter 2, most importantly the context within which the research takes place, the flexibility of the study as it adapts to the environment and collaborating with the teacher and the children.

Table 8 Wang and Hannafin (2005) Central Characteristics of Design-Based Research

Characteristics	Explanations
Pragmatic	Design-based research refines both theory and practice. The value of a theory is appraised by the extent to which principles inform and improve practice.
Grounded	Design is theory-driven and grounded in relevant research, theory, and practice. Design is conducted in real-world settings, and the design process is embedded in and studied through the design-based research
Interactive, iterative, and flexible	Designers are involved in the design processes and work together with participants. Processes are an iterative cycle of analysis, design, implementation, and redesign. The initial plan is usually insufficiently detailed so that designers can make deliberate changes when necessary.
Integrative	Mixed research methods are used to maximise the credibility of ongoing research. Methods vary during different phases as new needs and issues emerge, and the focus of the research evolves. Rigour is purposefully maintained, and discipline applied appropriately to the development phase.
Contextual	The research process, research findings, and changes from the initial plan are documented. Research results are connected with the design process and the setting. The content and depth of generated design principles vary. Guidance for applying generated principles is needed.

Wang and Hannafin, describe DBR as *'a flexible methodology that aims to improve educational practices through iterative analysis design, development, and implementation'* (2005, p. 6). This is based on collaboration between researcher and practitioner. The active role of the practitioner within this study is important for the development of the learning experience and the integration of the tool during playful activities in the classroom. The practitioner is the person on the ground with knowledge of the children, their personalities and how they interact with each other and the resources in the room. Thein et al. (2012) indicate that, in DBR, practitioners are not subjects assigned to treatments but instead are treated as co-participants in both the design and even in the analysis of a research process. Anderson and Shattuck (2012) highlight the effectiveness of building a collaborative partnership between researchers and practitioners. This methodological approach provides the opportunity to "*not only translate theory into practice but also to develop theory and improve practice*" (Wang & Hannafin, 2005). Alternative methodological approaches for this study would have been action research or a qualitative case study. Both of these will be looked at briefly in the next section and the rigour of a DBR approach.

4.6.2 Alternative approaches

4.6.2.1 Action Research

DBR shares some characteristics with action research in that it is process-based, iterative and incorporates participants input. There are some key differences between them. Action research in the classroom is primarily focused on one classroom's experience of the intervention and then aims to generalise that intervention as a secondary aim. DBR aims to solve problems during the intervention and inform theory throughout all stages of the study. Wang and Hannafin describe it as "more of a research paradigm than an evaluation method" (2005, p.9) because theory plays such an important role at all stages of the research. The theory leads DBR rather than being problem led as Action Research is. In addition, the goal of the design-based researcher "is to directly impact practice while advancing theory that will be of use to others" (Barab and Squire, 2004, p.8). Action Research in the classroom usually takes place with the teacher as lead researcher and does not include an integrated approach with external researchers. Due to the nature of this study, the iterative process, the emphasis on theory and practice and the researcher's position to participate in the research, DBR was deemed more appropriate for this study.

4.6.2.2 Qualitative Case Study

An alternative methodology considered for this study was a qualitative case study. Case studies offer a comprehensive understanding of a phenomenon by examining it from various perspectives, providing valuable insights into the broader application of a tool beyond the specific case. However, considering the study's goal of developing and designing an activity for language development and computational thinking (CT) skills integration within the classroom environment, Design-Based Research (DBR) was deemed the more suitable methodology. DBR allows for the iterative design process and adaptation of resources as needed.

Barab and Squire (2004) highlight that DBR goes beyond observing interactions by actively influencing and shaping those interactions that the researcher intends to study. In the context of this study, DBR was chosen because it facilitated the integration of research and design, allowing for the collaborative development of the activity with the teacher prior to addressing the research questions.

While a qualitative case study was considered as an alternative approach, DBR was selected as the most appropriate methodology for this study. The focus on integrating research and design, the iterative nature of the design process, and the collaborative development with the teacher all aligned well with the goals of developing an activity for language development and CT skills integration.

4.6.2.3 Rigour in DBR

According to Design-Based Research Collective (2003), design-based research is "*empirical research*," so objectivity, validity, and reliability are all necessary to make the findings of design-based research meet acceptable standards. Leading on from this, Plomp (2007), Shavelson, Phillips, Towne, and Feuer (2003) point out that design-based researchers must meet and apply the guiding principles for scientific research to maintain the necessary rigour in their findings. Accordingly, Plomp (2007) suggests employing Shavelson et al. (2003) guiding principles for scientific research. Their six guiding principles that underline all scientific research;

1. pose significant questions that can be investigated empirically;
2. link research to relevant theory;
3. use methods that permit direct investigation of the question;
4. provide a coherent and explicit chain of reasoning;
5. replicate and generalise across studies; and
6. disclose research to encourage professional scrutiny and critique. (pp. 3–5).

The adoption of these principles for this study maximised the rigour without jeopardising any of the qualitative features afforded by DBR research. During this research, every effort was made to enhance scientific rigour through observation of the proposed guidelines by Shavelson et al. (2003).

4.6.3 Child voice

According to the United Nations (1989), within research, children are recognised as possessing their own agency and inherent power, rather than merely being defined by the societal roles imposed upon them by adults. Corsaro (1987) suggests that children and adults alike are active participants in the social construction of childhood and the reproduction of their shared culture. "*What does it mean to be in this place?*" is a question used in the Mosaic Approach from Moss & Clark (2005) in gathering a child's voice. This approach of recording the child's voice allows the child to look at themselves and their environment and reflect on their perspectives of that environment. The child is also encouraged to give insight into what goes on in that environment. The environment in this study is the classroom. Keeping in mind the constructivist approach to learning where children find meaning in what they do, children are given the opportunity to reflect on their own experience of the activity rather than an abstract idea (Mac Naughton, 2003). The key elements of the Mosaic approach were considered when developing opportunities for the child's voice to be recorded before, during and after this activity. The researcher and the teacher play a key role in listening and documenting the child's voice.

Clark (2005) outlines these key elements as follows:

- Multi-method: recognises the different 'voices' or languages of children.
- Participatory: treats children as experts and agents in their own lives.
- Reflexive: includes children, practitioners, and parents in reflecting on meanings and addresses the question of interpretation.
- Adaptable: This can be applied in a variety of early childhood institutions.
- Focused on children's lived experiences: can be used for a variety of purposes, including looking at lives lived rather than knowledge gained, or care received.
- Embedded into practice: a framework for listening that has the potential to be both used as an evaluative tool and to become embedded into early years practice.

Including children's voices in research can enhance the quality of the research, improve the relevance of the findings, and promote child-centred practices (Alderson & Morrow, 2011). Including children's voices in research can have a number of benefits. Firstly, it enhances the overall quality of the research, leading to more robust and reliable outcomes (O'Brien et al., 2012). Secondly, incorporating children's perspectives and experiences results in findings that are more relevant and applicable to their lives and needs (Alderson & Morrow, 2011). Additionally, involving children in research empowers them, fostering a sense of agency and active participation in decision-making processes. Moreover, this approach promotes child-centred practices, ensuring that research and policies take into account the best interests of children (Coyne, 2010). Furthermore, it upholds ethical standards and human rights principles, advocating for the well-being and protection of children within the research context (Lundy, 2007). By embracing children's voices, researchers can gain deeper insights and make meaningful contributions to the improvement of children's lives.

To ensure that children's voices are heard in research, researchers need to use age-appropriate methods that enable children to express their thoughts, feelings, and experiences in ways that are meaningful to them (Alderson & Morrow, 2011). This can involve using methods such as child-friendly interviews, participatory activities, and creative techniques (O'Brien et al., 2012). Additionally, researchers should be mindful of power imbalances between adults and children and work to create a safe and supportive environment where children feel comfortable sharing their views (Alderson & Morrow, 2011).

Overall, the inclusion of child voice in research with young children is essential for promoting ethical practices, improving the quality and relevance of research, and empowering children to participate in decisions that affect their lives.

Questionnaires can be an important tool when conducting research with young children, as they allow researchers to collect data about children's experiences, attitudes, and behaviours in a standardised and systematic way. Here are some reasons why questionnaires can be useful in research with young children:

Positives:

1. Standardisation: Questionnaires can provide a standardised way to collect data, which allows for more objective comparisons between children and groups of children. According to a study by Alfonso, Allison, and Yeaton (1990), standardised questionnaires can help researchers to obtain reliable and valid data, and can increase the internal consistency of the data.

2. Large sample size: Questionnaires can be distributed to a large number of children, which can increase the sample size and improve the statistical power of the study. As noted by Strassberg and Stone (2017), questionnaires can allow researchers to collect data from a wide range of children, which can increase the generalisability of the findings.
3. Cost-effective: Questionnaires can be a cost-effective way to collect data, especially if they are administered online or through email. According to a study by Boustani, Ladrón de Guevara, and Rodríguez (2017), online questionnaires can reduce the costs associated with printing, mailing, and data entry.
4. Ease of analysis: Questionnaires can be easily coded and analysed using statistical software, which can help researchers identify patterns and relationships in the data. According to a study by McMorris, Hemphill, and Toumbourou (2007), questionnaires can provide quantitative data that can be analysed using a range of statistical techniques.

There are some negatives to using questionnaires with young children which includes; difficulty in understanding; limited response options; social desirability bias; and low response rate.

1. Difficulty in understanding: Young children may have difficulty understanding the questions in a questionnaire, especially if the language or vocabulary is too advanced for their age. As noted by Schmidt, Leventhal, and Coups (2007), young children may have limited vocabulary and cognitive abilities, which can make it difficult for them to understand the questions and respond accurately.
2. Limited response options: Questionnaires may limit the range of responses that children can give, which can restrict the depth and nuance of their answers. According to a study by Goodman and colleagues (2003), closed-ended questions can limit the ability of children to express their thoughts and feelings, and may not capture the complexity of their experiences.
3. Social desirability bias: Children may feel pressure to answer questions in a way that they think will please the researcher, rather than expressing their true thoughts or feelings. As noted by Piacentini and colleagues (2002), young children may be especially vulnerable to social desirability bias, as they may want to please the adults around them.
4. Response rate: The response rate to questionnaires can be low, particularly if children are not motivated to participate or if parents do not provide consent. According to a study by Garcia and colleagues (2017), low response rates can

be a problem in research with young children, and may limit the generalisability of the findings.

4.7 Research instruments

The main research instruments chosen for this study were focus groups, questionnaires, recordings of children's interactions, classroom teacher interviews, and teacher's reflective journal. More than one data source will be used to answer each of the research questions. Figure 8 shows the cycle in which of these research instruments were used. A rationale will be included as to why each of these datasets was chosen and the individual application of each type. Table 6 outlines the datasets that will be used to answer each of the research questions.

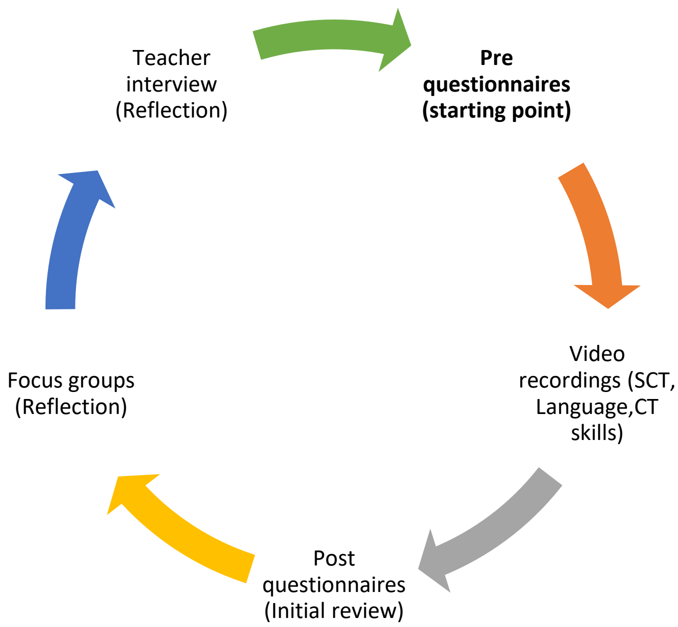


Figure 7 The cycle of research instruments

4.7.1 Recordings of the activity

Recordings of children's interactions with each other as they engage in activities are well-established as effective means in capturing young children's learning and in particular their language learning (Dörnyei, 2007). The recordings from this research provided extensive data on the children's SLL use during the activity and how frequently the target language was used. Classroom-based research and small group research provides the opportunity to situate the research in a real-world context for the children, an environment that they are comfortable and familiar with. During the research activity, a camera was placed in front of the group to capture their conversation, their movements, and their inputting of directions into the floor robot. These recordings were used for the analysis of the children interacting with each other, with their teacher and with the robot. The recordings were also used to analyse the children's use of the target language from their Irish language lesson and the directions they inputted into the Bee-Bot. Recordings like this can provide authentic language use for analysis (Bachman and Cohen, 1998). For this study, the recording took place in the children's classroom. As in line with the principles of DBR, classroom-based research provides an authentic environment to situate research and allows the researchers to consider the broad range of interactions that happen in the classroom during the research activity. It also provides an insight into the child's real experience of the activity in their own learning environment. The classroom was an important factor in the research project due to the ecological goals set out in chapter 1. Undertaking research like this can present challenges to the researcher's analysis of the activity. These challenges included interruptions to the activity as children at other activities required support from the teacher, this was disruptive to the flow of the activity; the changing school calendar as whole school activities were scheduled and conflicted with the activity recordings; children absent from school. Illness impacted cycle 4 of the research as the children contracted chickenpox. This made it difficult to maintain a well-defined sample for tracking progress (Dörnyei, 2007). Communication with a wide range of stakeholders- principal, teacher, parents, and children can also prove challenging. The researcher collaborated with the classroom teacher and visited the classroom regularly, and all stakeholders were made aware of these classroom visits.

4.7.2 Focus group interviews

Focus group interviews were selected as one of the most appropriate data collection methods for this project due to the age of the children and the focus of the research. The focus group interview is a method of group interview where research participants are encouraged to co-construct the meaning of a given phenomenon (Bryman, 2016, p. 501). The gathering of data through the child's voice is not a new concept, especially in the field of educational research. Generally, researchers promote the collection of data through such sources as it may empower children to "… *participate meaningfully and collaboratively in improving their experience of school"* (Flynn, 2017, p. 9). There are a number of benefits in using focus groups in qualitative research, particularly with young children. The focus group creates an informal conversation in a familiar environment. This creates a relaxed atmosphere where the children can engage with each other and with the researcher. The children can play a more active role in leading the conversation as different focus points about the activity arise, which may not be possible in a more formal setting (Liamputtong, 2011). As is recommended by several authors, small groups of children were taken to the corner of the room or a separate room adjacent to the classroom in pairs or groups of three for a focus group after the activity (Graue & Walsh, 1998; Greig, Taylor, & MacKay, 2012; Mayall, 2000). Focus groups with young children should be established within an environment with which they are familiar. Junior and senior infant children in a primary school setting are familiar with working as individuals, in whole-class activities and in small group activities as set out in the research activity. A focus group is less conducive to getting to know individual children's experiences, but it does offer the opportunity for understanding their experience (Freeman, 2009, p. 103). The group interaction during a focus group is seen as an important part of generating data. *"Instead of asking questions of each person in turn, focus group researchers encourage participants to talk to one another: asking questions, exchanging anecdotes, and commenting on each other's experiences and points of view"* (Barbour & Kitzinger, 1999, p. 4) In some situations, the group dynamic is the focal point for the research. When children are together in conversation, they engage their social and cultural worlds as they interact together, agree, disagree, laugh, or get upset. This is true of both the focus groups and the research activity.

It has also been established that small groups such as the focus groups used in this research are an effective way to keep children truthful with their answers (Einarsdóttir, 2007). Children are more relaxed and comfortable when they are together instead of being interviewed in a one-to-one environment. They feel more powerful with a friend beside them rather than isolated with an adult (Eder & Fingerson, 2003; Einarsdottir, 2003; Graue & Walsh, 1998; Greig et al., 2012; Mayall, 2000; Parkinson, 2001). It is important when undertaking focus groups that it is not "just getting a bunch of people together to talk." A focus group is a special type of group in terms of purpose, size, composition, and procedures" (Krueger & Casey, 2009, p. 2). There are a number of considerations when undertaking focus groups for research. The quality and phrasing of the questions are so important as Liamputtong outlines, "If there are too many questions if they are not asked specifically, and if there is no follow-up for clarification, these factors can affect the quality of information gathered" (Liamputtong, 2011, p. 47). The role of the researcher is fundamental to the success of the focus group methodology. Focus groups are frequently utilised to gain insights into specific aspects of children's collective viewpoints or experiences. The primary goal is not merely to hear individual opinions but to foster group discussions that generate knowledge based on their direct experiences (Freeman, 2009, p. 103). Researchers often prefer group interviews as they believe they encourage children's active participation by reducing the influence of adult authority, lessening the pressure on individuals to respond, and fostering group support.

However, it is essential to be mindful of power dynamics within the group, as some children may dominate the conversation, affecting the interaction and involvement of other group members. During data analysis, close attention should be paid to the group dynamics and how meaning is negotiated, as it is possible for a few children to significantly influence the discussion.According to Dörnyei,

> *Focus group interviews – as the name suggests – involve a group format whereby an interviewer records the responses of a small group…The focus group format is based on the collective experience of group brainstorming; this is, participants, thinking together, inspiring and challenging each other, and reacting to the merging issues and points. This within-group interaction can yield high-quality data as it can create a synergistic environment that results in a deep and insightful discussion (*Dörnyei, 2007, p. 144*)*

In the focus group, the children were asked the same questions from the post-intervention questionnaire. During this time, they had the opportunity to add more dialogue to their answers instead of directly answering the happy face or sad face. This allowed the children to discuss the questions with each other and facilitated gathering their perspectives on their use of Irish and technology and whether they found the activity to be useful or not. A video camera was used to capture the children's movements and voices during the focus group.

4.7.3 Video Stimulated Recall (VSR)

The researcher incorporated Video-Stimulated Recall (VSR) in cycle 4 of the research intervention. This decision followed difficulties observed in cycles 2 and 3 focus groups, where children had trouble recalling the Bee-Bot activity. To address this, short video clips of the children participating in the activity were shown at the beginning of each focus group session. This approach aimed to tap into children's accounts of their own lives and perspectives, recognising the importance of their voices in the research, which aligns with Mayall's (2002) perspective.

Theobald (2012) outlines that the video-stimulated session is similar to a well-known research method used in second language learning studies, video-stimulated recall (Allison, 1987, 1990; Calderhead, 1981; Dunkin et al., 1998; Gass, 2001; Gass and Mackey, 2000; Keyes, 2000; Stough, 2001). Both methods involve showing a portion of the video recording to the research participants who were involved in the activity (Theobald, 2012).

However, when employing a video-stimulated session with a talk-in-interaction perspective (Sacks, 1992), three methodological differences become apparent, distinguishing video-stimulated accounts from video-stimulated recall. Firstly, video-stimulated recall emphasises participants' memory of events, aiming to explore their thoughts and considerations at specific moments during the recorded incident. Conversely, video-stimulated accounts focus on interactional aspects, as accounts are constructed during the process. Secondly, the context in which the reports are generated varies between the two methods. Finally, the treatment and analysis of the reports that emerge when participants view recorded segments differ between video-stimulated recall and video-stimulated accounts (Theobald, 2012). Video-stimulated recall is commonly used by researchers to understand what participants were thinking at a given point in time during the incident or to test their memory of an event (Theobald, 2012).

4.7.4 Teacher's interview

An interview with the classroom teachers took place after the activity during both pilot cycles and once a week during the third cycle. An audio recording will be made of this interview, and which will be transcribed immediately afterwards together with reflections from the researcher. The questions during this interview will encourage the teacher to reflect on the research questions and the design of the study. The teacher will be asked to consider the children's behaviour and motivation before and during the activity and what moments stood out to them. The teacher's approach to the design of the lessons and the integration of the target language into play will also be discussed. The teacher is best placed to recognise the children's motivation to engage in the activity and use the target language.

4.7.5 Questionnaires

Questionnaires are a useful and popular method of data collection in language research. Brown describes questionnaires as: "any written instruments that present respondents with a series of questions or statements to which they are to react with by writing out their answers of selecting from among existing answers" (Brown, 2001, p.6.). Questionnaires also provide factual, behavioural, and attitudinal data (Dörnyei and Taguchi, 2010). This is one of the reasons why researchers use questionnaires, along with their efficiency and cost-effectiveness. However, this is very different when researching with a younger cohort of research participants. As mentioned in section

4.6.1 there are limitations to quantitative approach with young children. A challenge that questionnaires present is the need for rigour so that the information provided by the research participant is valid. When creating a questionnaire, a researcher must consider "the form of the questions, the meaning of the questions and the reactions of the respondents" (Brown, 2001, p.9). Brown extends this description by outlining that questionnaires should measure what they are supposed to measure and maintain consistency. A disadvantage of using questionnaires is that they do not provide sufficient information to explore the participant's perspective on the content of the research activity. Quite often, the data retrieved from questionnaires can be surface-level information (Dörnyei & Taguchi, 2009). To avoid the risk of insufficient data Gilham (2008) recommends triangulation to support any research claims. A limitation of questionnaires with young children is that it is often difficult to ascertain whether children are answering truthfully. Their answers may mirror their classmates, and the questionnaire may not reflect their true feelings on the topic (Dörnyei & Taguchi, 2009). The questionnaire in this study (Appendix G) is a list of statements to which the children could answer yes or no. The panel of teachers who assisted the researcher in developing this list deemed a list of statements more effective than questions, which may include a Likert scale. The children were reassured throughout the questionnaire process that they could answer whatever way they wanted to and that there was no right or wrong answer and that the researcher really wanted to know their opinion. There is another limitation to this process with young children that they may give the answer they believe the researcher, or their class teacher wants to hear (Bell, 2007). For effective response to questionnaires children must move through four cognitive stages to execute the *optimising strategy* (Schwarz and Sudman, 1996; Tourangeau, 1984).

> *First, the respondent comprehends the question. This involves coming to an understanding both of the terms used in the question and of the task he is being asked to perform in order to answer it. Second, he retrieves from memory the information required to answer it. Third, he has to make a judgement about the information needed to answer the question. Finally, he communicates his response. This may involve editing his initial answer, which he might feel portrays him in a 'negative' light, to something that he believes makes him look better*

Bell, 2007

In the past two decades, the significance of conducting questionnaires with children during research has increased. This is due to the recognition that the child's perspective is crucial, and relying solely on the voice of adults as proxies is no longer sufficient (Scott, 1997). While gathering the teacher's viewpoint remains important for data collection in this study, quantitative research with the children holds equal importance because society now acknowledges children as social and economic actors in their own right (Bell, 2007). By allowing children to provide direct input, more reliable information about their attitudes and outlook on specific areas of their lives can be obtained, rather than depending solely on adult perceptions (Bell, 2007).

There is a growing understanding in various research fields that children lead complex, multi-faceted lives, potentially different from how adults remember their childhood experiences. This departure from the positivist approach, which categorised all children based on stage and developmental expectations (Piaget, 1990), reflects a trend towards acknowledging the historical and cultural influences that shape each child's unique experience of childhood (Vygotsky, 1978). Although researchers and educators still have much to learn about children and their experiences directly from children themselves (Dockett & Perry, 2007), it is evident that children actively shape their worlds while also being shaped by their surroundings (Kincheloe, 2004: xii).

Table 9 Datasets that will be used to answer each of the research questions

Research question	Instruments used in order of relevance to question
1. What are children's attitudes towards using robotics for second language learning?	• Focus group recording • Activity recordings • Teacher’s interview • Questionnaires
2. What evidence of language learning can be observed during a robotics-based intervention and what are the processes that support this learning?	• Activity recordings • Teacher’s interview • Focus group recordings • Samples of children’s work • Teacher’s reflective diary
3. What evidence of the development of computational thinking skills can be observed during a robotics intervention and what are the processes that support this learning?	• Activity recordings • Teacher’s interview • Focus group recordings • Teacher’s reflective diary

4.8 Data analysis

Introduction

The data gathered for the research study was stored securely and complied with GDPR guidelines from Trinity College Dublin. The research supervisor and the researcher have access to the data. The data was filed according to each cycle and with an additional file under each to include feedback and recommendations for the next cycle. Different methods of analysis were used on different sets of data. The pre and post questionnaires were compiled and scored for pre and post activity analysis. Descriptive statistics was used in the analysis of the questionnaires to identify a change in perspective from the overall group in each cycle. Thematic analysis was used for analysing interviews with the teachers and focus groups with the children. Emerging themes from both data sets were used to support findings from the video recordings. The activity transcriptions were coded for Irish language usage, SCT constructs and CT skills. A set of codes were identified through the literature review, which informed the coding of SCT and CT skills. The coding of the transcripts was carried out using the CLAN software. This section will elaborate on each of the methods of data analysis employed for this thesis.

4.8.1 Questionnaires

Two questionnaires were used during the research, pre-intervention, and post intervention. The questions are listed in Table 7. The pre-intervention questionnaire was designed alongside a group of primary school teachers who are based in the early primary setting, junior and senior infants. The questionnaire began as a long list and was refined to five questions for the pre-intervention questionnaire and nine for the post-intervention questionnaire, which targets the child's opinion on Irish in school and using technology. During cycle one, the children had the option of answering yes or no to these questions by colouring in a smiling face or a sad face. Feedback from this cycle indicated, that an additional option should be made available to the children when answering the questionnaire. This is discussed further in section 5.4.1.1. The answer options were amended to include a neutral face which would indicate “I’m not sure” (Appendix G and H). During pilot cycles one and two, the children completed both the pre-intervention and post-intervention questionnaires on the same day. During the cycle 4, there were 27 children in the class. While all the children did not have consent to participate in the recording of the activity, all children participated in answering the questionnaire. In total, 22 children answered the questionnaire as five children were absent on the days the questionnaire was given pre and post intervention. Results are provided in section 7.2.1 in the format of standard deviations due to the small size and limited answering options provided to the children.

4.8.2 Coding

The process of transcription has come a long way from being typed onto stencils so that copies could be printed. From the nineteen eighties onwards, the use of personal computers and the internet opened up the possibility of databases and analytical programs. This provided the opportunity for academics to share transcriptions and coding methods, which would have been impossible a few years before.
Brian MacWhinney comments on this period:

> *[T]he possibility of utilizing shared transcription formats, shared codes and shared analysis programs shone only as a faint glimmer on the horizon, against the fog and gloom of handwritten tallies, fuzzy dittos, and idiosyncratic coding schemes. Slowly, against this backdrop, the idea of a computerized data exchange system began to emerge.* MacWhinney (2010, p. 8)

From an uncertain beginning in 1981, MacWhinney and Catherine Snow went on to develop a system for the study of first language acquisition. Drawing on the expertise of a large number of researchers, the Child Language Data Exchange System (CHILDES) database was established, along with a transcription format (CHAT) and an analysis programme (CLAN). The first set of manuals was published in 1991. Today, CHILDES is the world's largest corpus of spoken language data, containing over 44 million words from 28 different languages. As well as data collected over the last two decades, it also includes earlier corpora. The extent to which the system has facilitated research can be judged from the fact that a 2002 review identified more than 2000 articles that had used the CHILDES data or the programs (MacWhinney, 2008). The video recordings that provided the data for this study have been transcribed by the researcher into CHAT format and analysed with the help of the CLAN programs. The resulting corpus consists of 27,788 words.

Table 10 Total corpus from each day cycle 4

Corpus	Green	Orange	Purple	Yellow
Day 1	1717	986	1672	1440
Day 2	1795	1662	1692	1871

Day 3	1723	1361	1636	1948
Day 4	1287	1724		1516
Day 5	1390	1285		1083

The CHILDES project is mainly concerned with research in first language acquisition, and the CHAT format was designed and developed for the transcription of recordings of face-to-face conversational interactions. The CHAT manual gives specific symbols for coding transcripts; the coding can be adjusted, and codes specific to a study can be added. There were two levels of analysis in the video recordings for this study. The first was analysing what the children were saying, and the second was their actions. The videos provided the audio of the teacher interacting with the child, the children interacting with each other and the children interacting with the robot. The video recordings also provided a visual of the child inputting a code into the robot during the activity and gestures made while discussing it. Each of these videos was transcribed and coded verbatim. The total corpus is outlined in Table 6.

Table 11 Coding SCT constructs

CHILDES codes	
Concept	CLAN Coding format
Zone of Proximal Development (ZPD)	%sct: $ZPD: CHI
Mediation	MED: CHI: BOT: TEA Mediator: Child: Robot: Teacher " $MED: MKO: TEA: CHI
Regulation	" $MED: CHI:REG
Internalisation	" $MED: CHI: INTE
Private Speech	" $MED: BOT:PRI
Scaffolding	SCA: CHI: BOT: TEA Scaffolding: Child: Robot: Teacher " $SCA: CHI: BOT: TEA

Distinguishing between transcription and coding, MacWhinney (2010, p. 17) says: "Transcription focuses on the production of a written record that can lead us to understand, albeit only vaguely, the flow of the original interaction." For this study, transcription was carried out as a first step; the second step included adding a second layer of actions associated with the transcribed speech. The actions noted took place while the child was speaking and also actions that took place with no utterances from the child. A third step was to review the videos and identify the SCT and CT codes that were set out prior to the data analysis. The transcripts were coded through observation, analysing the transcripts and through a review of the actions taken by the children. Facial expressions, scaffolding from the teacher and tone of speech were all important factors during the coding process. For the purposes of this study, it was necessary to make some additions to the code set that already exists in CHAT. As this study was investigating SCT constructs and CT skills, a specific set of codes was added to the CHAT. These codes were derived from the literature on both areas as outlined in Table 7. As these constructs and skills were identified within the transcript, they were inserted under the text.

Some SCT constructs the researcher was able to code in the transcripts; however other constructs such as ZPD were observed through watching the video recordings a number of times and recognising the developmental shift within the children and their reduced need for mediation from objects and from others and their move to self-regulation. As previously outlined in the literature review section 2.2.5, a child's ZPD is often recognised retrospectively. The transcripts required cycles of reviews to ensure consistency across all transcripts. Through consultation with the research supervisor, spot-checking on the coding of the transcripts took place. Throughout this process, patterns began to emerge within the transcripts, which assisted the researcher during the analysis phase.

The format of language analysis was as follows (Approximately 12 weeks):

1. Transcription of recordings
2. Physical actions/gestures during activity: this was noted where applicable within the transcriptions
3. Coding for SCT constructs and CT skills: Transcripts were analysed with recordings, coding was added where appropriate
4. Analysis of total output of language from each child each day
5. Analysis of total Irish output from each group and each child (daily)
6. Analysis of total social/target and functional language used each day
7. Comparison of English to Irish language used each day
8. Teacher's language analysed (Point 4, 6, 7)

Through the use of CHILDES software, the researcher calculated the number of times each SCT construct was coded in the transcripts. While some constructs were consistently observed throughout the data, other constructs featured gradually over the six weeks and were identified in the language used by the children and during their CT skills development.

CHAT was also used to analyse the use and frequency of Irish during each session and by each individual child. CHAT can be set to identify 28 different languages within CHILDES. As the primary focus was on second language learning, the researcher sought to compile a list of all the Irish words used and their frequency. By running a frequency code on the transcript, the Irish language that was being used by the children was identified and categorised as social, target and functional language. An additional analysis was carried out by hand on each of the transcripts to ensure that all Irish words were identified.

CHAT was finally used for the coding CT task. Each time a child was given a task to complete with Bee-Bot the directions the child inserted into Bee-Bot were noted in the transcript. If Bee-Bot successfully stopped on the target this was noted in the transcripts and if Bee-Bot did not make it to the target this was noted. To ascertain how many attempts, it took the child to complete the task set out by their teacher or another child in the group, the researcher counted the number of attempts by hand and compiled these results on data tables which can be reviewed in Appendix X. The results from these calculations are presented in section 7.5.

4.8.3 Thematic analysis

Thematic analysis was used during the analysis of the teacher interviews and the focus groups. The process of thematic analysis is to identify patterns or themes within qualitative data, i.e., interview or focus group transcripts (Maguire & Delahunt, 2017). Braun and Clarke (2006) outline that it is the first qualitative method that should be learned as '...*it provides core skills that will be useful for conducting many other kinds of analysis*' (2006). An additional advantage to thematic analysis is that it is a method rather than a methodology (Braun & Clarke, 2006; Clarke & Braun, 2013). This means that, unlike many qualitative methodologies, it is not tied to a particular epistemological or theoretical perspective. This makes it a very flexible method and suitable for this design-based research study. These sections of data (teacher interview and focus groups) follow Braun and Clarke (2006) six-step framework for thematic analysis as set out below.

Braun and Clarke (2006) six-step framework for thematic analysis	
1.	Familiarising yourself with your data: Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas
2.	Generating initial codes: Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.

3.	Searching for themes: Collating codes into potential themes, gathering all data relevant to each potential theme.
4.	Reviewing themes, checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5.	Defining and naming themes: Ongoing analysis to refine the specifics of each theme and the overall story the analysis tells, generating clear definitions and names for each theme.
6.	Producing the report: The final opportunity for analysis. Selection of vivid, compelling extract examples, the final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Thematic analysis is the most influential approach within the social sciences as it offers a clear and easy to use framework for doing thematic analysis (Maguire & Delahunt, 2017). There is much more to thematic analysis than summarising data. When doing thematic analysis, the researcher must interpret the data and make sense of it. Clarke and Braun (2013) highlight a warning when doing thematic analysis to not focus on the interview questions as themes. This shows that data has been summarised and organised rather than interpreted and analysed. Thematic analysis was carried out on data collected from the children’s focus groups and the teacher’s interview in cycle 4 as the pilot cycles were for testing the research instruments.

4.9 Triangulation

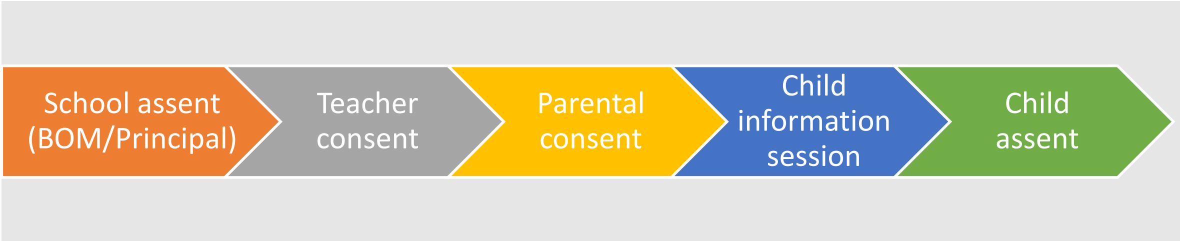
Campbell and Fiske's seminal article in 1959 formalised the use of multiple research methods, introducing the concept of triangulation, which involves employing multiple methods to validate research findings and ensure that the observed outcomes are attributable to the activity itself rather than the chosen method (e.g., quantitative or qualitative) (Campbell & Fiske, 1959).

Bouchard (1976) further emphasised the significance of convergence of findings from different methods, which enhances the confidence in the validity of the results and minimises the possibility of methodological biases. Johnson and Onwuegbuzie (2007) credit Campbell and Fiske (1959) for pioneering the explicit use of multiple research methods for validation purposes. Webb et al. (1999) are acknowledged for coining the term 'triangulation', which involves using two or more independent measurement processes to confirm a proposition, thereby reducing the uncertainty in its interpretation. Triangulation involves cross-validating data sources, data collection strategies, time periods, and theoretical approaches (McMillan & Schumacher, 2006). By adopting this approach, researchers aim to gain a comprehensive understanding of the research context from different perspectives. It is essential to note that while triangulation provides valuable insights, researchers must exercise caution in using it as a means to uncover a single definitive interpretation of reality. Different perspectives may shed light on various aspects of the phenomenon under investigation, but they may not necessarily lead to a singular "truth."

In the present study (as mentioned in section 4.7), several data sources were employed to address the research questions. Triangulation was utilised to ensure the comprehensiveness and validity of the collected data. This process facilitated a detailed analysis, identification of patterns, and comprehensive exploration of each research question. By employing triangulation, the study aimed to offer an informed and well-rounded understanding of children's perspectives on language and CT skills development with robotics.

4.10 Ethics

As the study involves children under the age of 18, ethics is naturally a consideration before conducting the research. The areas of concern are that the children feel comfortable and safe in their classroom environment while the researcher is present and while they are being recorded by a video camera. Informed consent was required from the school, the parents and assent from the children before the commencement of the study. Children's anonymity is a priority as they will both be filmed and asked for individual responses in a questionnaire. A consultation will take place with each participating school principal and classroom teacher, together with the School of Education Ethics committee, to ensure that ethical standards are met throughout this study. The School of Education Ethics committee has approved an ethics application for this research. The research was carried out in each school in compliance with the standards set out by the committee and in line with local guidelines. Open dialogue will be maintained between the researcher and the research supervisor, and, if necessary, the School of Education Ethics committee will be consulted.



As has been well-established in early childhood research, the child voice approach is an important and ethical way to involve children in research *(*Dockett, Perry, & Kearney, 2013*).*

Ethical considerations regarding the children's comfort and security were taken into account when selecting the appropriate year group for the study, which was conducted within the early years of primary education. Steps were carefully taken to ensure best practices were followed when engaging with the school and the children. Permission and consent were sought for the intervention, and this process will be outlined in the following section.

Maintaining anonymity for research participants is a standard practice in research, and this is typically achieved by using pseudonyms and providing general descriptions of the context rather than specific details. However, when research data includes video recordings, ensuring anonymity becomes more challenging. Flewitt (2005) highlights that video and photographic data's public nature can cause anxiety among participants, particularly regarding concerns about losing control over how the data may be used.

To address these concerns, Flewitt (2005, pg. 559) offers several suggestions for using video data ethically, which include:

- Allowing all participants to view and comment on the data to ensure their understanding and agreement with its usage.
- Providing participants with their own copies of the data to empower them with more control over its use.
- Seeking specific consent from adult and child participants for the use of particular video data in research.
- Carefully considering the level of visual detail required for research reports and presentations, potentially obscuring faces to avoid recognition or reducing the pixel count of the image to create a "fuzzy" effect.

By implementing these strategies, researchers can better uphold ethical considerations while working with video data, respecting the privacy and preferences of the participants involved in the study.

4.10.1 School consent

The researcher discussed the project with the principals and addressed any questions or concerns that they had. The principal discussed the research with the junior infant/senior infants' teachers in the school to ascertain if they were interested in the project. If a teacher was willing to participate, they received an information sheet and a consent form. As this project requires close collaboration with the teacher, a more in-depth discussion was be held to ensure that they are informed. The researcher will also ensure that the research supervisor is aware of any issues that arise from these conversations. Dates for the data collection will be finalised with the school, and parents will receive the information sheet and consent form promptly to ensure they have enough time to develop an informed opinion regarding consent. When all consent forms were returned to the teacher, an information session was held with the children. Both the teacher and the researcher were present for this session, and an assent form containing three questions was given to the children.

4.10.2 Parental consent

As per the Trinity College Dublin ethical guidelines, the consent of a parent or guardian must be sought for any child under the age of 18. The appropriate consent form was sent to parents/legal guardians of the children in the classes that participated in the study. The parents were given an information sheet about the researcher, the research supervisor, and the proposed study. Information was given on the data that would be collected, i.e., questionnaires, recordings, photographs, drawings, and a focus group recording. Information was included about how the data collected will be stored and for how long. Parents were assured in the information sheet that they were under no obligation to consent to the study, and they were free to withdraw their children from the study up to a certain point. The parental consent form can be seen in Appendix D.

4.10.3 Child assent

Incorporating an additional layer of child assent not only aligns with the legal requirements of The Convention on the Rights of the Child (United Nations, 1989) but also demonstrates a genuine commitment to respecting children's participation (Dockett et al., 2013). Seeking assent from young children reflects the recognition that children are competent social actors, and as such, research methodologies and approaches must be relevant and meaningful to them. This approach does not advocate treating all research participants the same or absolving researchers of their responsibilities to care for children. Instead, it underscores the importance of tailoring research practices to consider the needs and perspectives of the child participants, using appropriate methods and strategies.

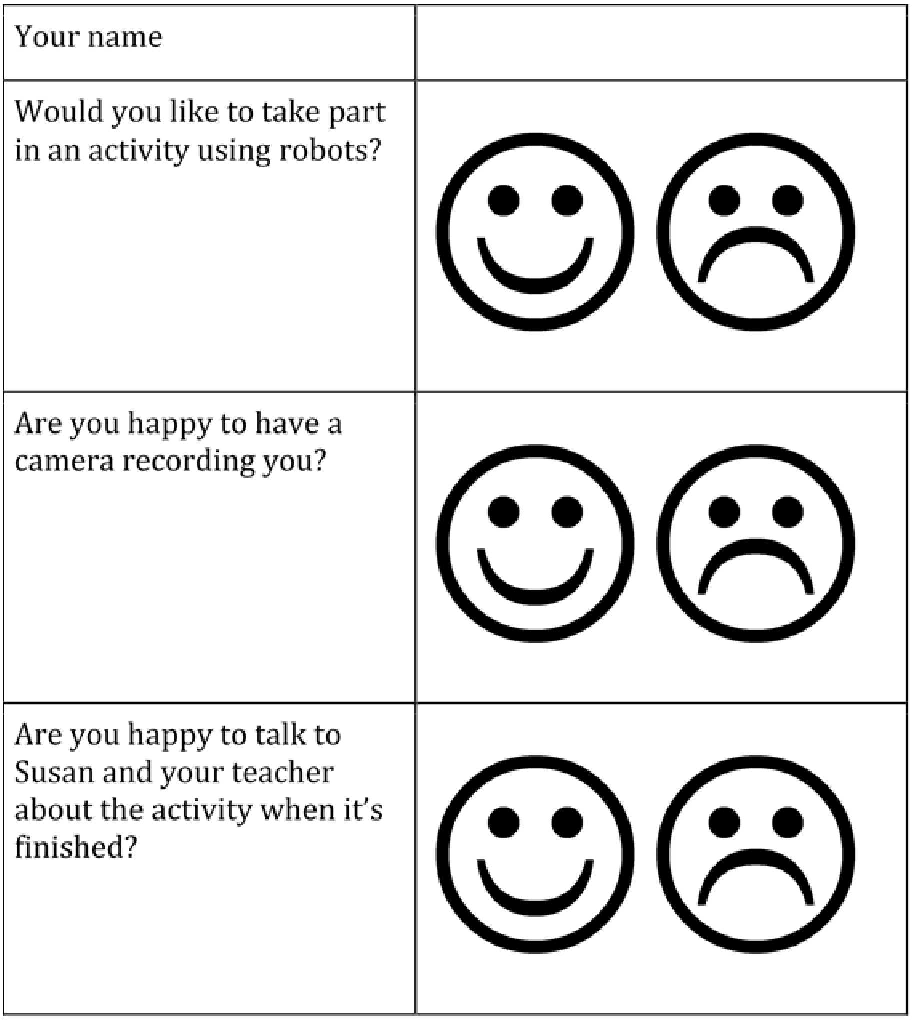
Article 12 of the United Nations Convention on the Rights of the Child (United Nations, 1989) emphasises the child's right to express their views on matters that affect them. As researchers, it is our duty to ensure that children have the opportunity to exercise this right in research. Obtaining informed consent involves providing ongoing opportunities for children to assess what is being asked of them and to have the choice to continue or withdraw at any stage of the research process (Hill, 2005).

Flewitt (2005, p. 556) introduces the concept of *'provisional consent*,' which suggests that children's agreement to participate can be understood as provisional, subject to the research being conducted within a negotiated and flexible framework that aligns with the participants' expectations. This notion highlights the ongoing nature of consent throughout the research process.
Dockett & Perry (2007) outline that obtaining consent involves navigating various tensions. On one hand, researchers must ensure that sufficient information is provided so that potential participants can make informed decisions about their participation. However, it is also important to avoid overwhelming participants with an excessive amount of information (Dockett & Perry, 2007). Additionally, researchers must inform children about the potential positive and negative outcomes of research participation. Hill (2005, p. 69) identifies key factors that should be included in the information provided to children, such as the research aims, time commitment required, who will know the results, whether there will be feedback, and promises of confidentiality. Taking these considerations into account allows for an ethical and respectful approach to involving children in research (Dockett & Perry, 2007).

The child assent form was incorporated into the parents' form, ensuring that parents were informed about the process of seeking their children's assent before the commencement of the activity. While adults are required to provide written consent, obtaining children's written consent may not always be appropriate. Nevertheless, it should not be assumed that children are unwilling to exercise their right to give written consent, as they may express their agreement in various ways, such as writing their name or using a specific mark or sign (Dockett & Perry, 2011).

Hill (2005) emphasises that simply receiving a lack of refusal from children when asked about participating in research is insufficient; what is required is positive consent. This means that researchers must actively seek and obtain explicit agreement from children, rather than assuming their willingness to participate.

In this study, the process of obtaining both parental consent and child assent was carefully managed to ensure ethical considerations were met. The parents were made aware of the assent process, and children were given the opportunity to express their agreement to participate in the research, respecting their right to be actively involved in the decision-making process.



Your name	
Would you like to take part in an activity using robots?	
Are you happy to have a camera recording you?	
Are you happy to talk to Susan and your teacher about the activity when it's finished?	

Figure 8 Child assent form for participation (pilot study)

If parents did not consent to their child's participation in the activity, they were not excluded from the activity, but they were not recorded as they engaged with it. Children whose parents did consent to their participation were grouped together. On the day that they participated in the activity, no video camera was used, and no photos were taken of them. Separate information sheets and consent forms were prepared for both the pilot cycles and for six-week cycle four. Table 9 shows the assent form, which included a happy and sad face for yes or no answer. The children were familiar with this style of questionnaire from other curricular areas.

4.10.4 The rationale for child assent

In the field of early childhood literature, the terms 'consent' and 'assent' are often used interchangeably. Some authors, such as Hurley and Underwood (2002) and Powell et al. (2012), prefer to use the term 'assent' to refer to the agreement provided by individuals below the legal age of consent, indicating their willingness to participate in the research independently. Despite the distinction in levels of understanding, both 'consent' and 'assent' are founded on the same principles and are recognised as a "relational process whereby children's actions and adult responses taken together, reflect children's participation decisions" (Dockett & Perry, 2011).

Hughes and Helling (1991), in their research spanning over two decades, have identified challenges faced by researchers when attempting to engage children aged three to eight in the process of informed consent. The primary challenge lies in the fact that young children might struggle to fully comprehend and grasp the research process, impeding their ability to make informed decisions. Their limited experiences and developmental levels make it difficult for them to understand both the purpose of the research and their right to withdraw from participation (Hughes & Helling, 1991).

Palaiologou (2012) discusses an ideological shift wherein children's voices have become pivotal in research engagement. The Rights of the Child advocates for recognising and valuing young children for who they are in the present, rather than focusing solely on their future potential (Smith, 2011). Ethical considerations highlight the importance of involving children as active contributors in research (Kirk, 2007). This shift in thinking encourages researchers to embrace children's participation in research and emphasises the significance of ensuring that participants comprehend their role and the purpose of the research project, leading to what is known as 'informed consent' (Mayne et al., 2016).

Meaningful informed consent, as highlighted by Cocks (2006), comprises three essential components: the information provided by the teacher and researcher, the child's comprehension of the research and what it entails to participate, and the child's response to the information presented. However, gathering meaningful informed consent from children continues to be a crucial issue for researchers, as it involves addressing the best interests of children during the research process (James & Christensen, 2017; Harcourt, Perry, & Waller, 2011).

As this research involves gathering assent from children participating in the study, it is imperative to bear in mind the challenges and considerations associated with obtaining meaningful informed consent in the context of early childhood research.

4.10.5 Obtaining assent

Assent was sought for this study as the child's engagement, and their perspective is crucial to gathering data on their motivation to learn. By informing the children of the process and asking them for their assent, they are given the ability to voice their opinions and analyse the activity they are undertaking for the study. The children's assent was sought after the children were informed about the activity.

Children were given an information poster during the information session. The poster outlines in plain English what the activity entails; a camera and a video recorder will be used; that a focus group will be held after six weeks, and; that they have the right to refuse to be photographed and recorded. This poster will be hung up in the classroom as a reminder for the children throughout the activity (Appendix F). It was an important part of the ethical approach to this study that a provision was made for children to withdraw whenever they wanted (Green, 2015). The assent form will then be distributed amongst the children.

On the assent form, the children will be asked to fill in a happy face for yes and a sad face for no in response to three questions. The first question relates to their participation in the activity. The second question relates to permission from the child to be recorded with a camera. The children will be shown the camera at this point, and they will be told where it will be positioned during the activity and why this recording will be taken. The children will be made aware that both the researcher and the researcher's supervisor will be viewing this recording to see how they get on in the activity. The children will be reminded there is no right or wrong in the activity and will be encouraged to enjoy it. Children will be reminded of this as they may want to give the answer they think their teacher wants to hear or try and please the researcher as they're a visitor to the class. The final question relates to the focus groups and asks the children if they are happy to discuss the activity with the researcher and with their teacher. The children will be told that their teacher will always be with them during the activity, and if they are happy to discuss it afterwards in a group interview, their teacher will be present in the room also.

This point will be made clear to the children as they are familiar with their teacher, and they won't know the researcher as well. Children who do not assent to their participation will be grouped. On the day that they are due to participate in the activity, no photographs or recordings will be taken of them. They will not be excluded from the activity in class.

4.11 Limitations

This chapter introduces the conceptual and methodological approaches adopted for the research, carefully chosen to gather comprehensive data and address the research questions outlined in section 4.1. The iterative nature of the research activity was also facilitated by these approaches. However, it is essential to acknowledge that this approach had certain limitations, as pointed out by Barab and Squire (2004), who emphasised the challenge of ensuring credibility and trustworthiness when the researcher is deeply involved in the entire process, from conceptualisation to implementation and analysis.

Qualitative research methods, including Design-Based Research (DBR), often contend with the issue of researcher bias, with proponents arguing that researchers' insights and understanding of the context can be valuable research tools. To minimise this concern, Johnson et al. (2007) propose that while inside knowledge is valuable, researchers should maintain a level of skepticism, commitment, and detachment to ensure research validity.

Despite the study's limitation in terms of a small sample size and a short duration (one classroom with one teacher over six weeks), the research effectively examined the floor-programmable robot's impact on language learning and development. To fully understand the tool's potential impact in various classroom settings over a more extended period, it should be tested in multiple classrooms with different teachers. Nonetheless, this study's primary goal was to investigate the tool's effectiveness for language learning and computational skill development in the early years, and it lays the groundwork for future research in this area.

DBR projects face additional challenges due to the need for multiple cycles of investigation. Herrington, McKenney, Reeves, and Oliver (2007) have addressed this concern and demonstrated how DBR can be employed for a doctoral dissertation over an extended period. Establishing multi-year DBR research agendas, as seen in other scientific disciplines, could provide a partial solution to this issue and allow graduate students to contribute significantly to the larger research agenda.

This design-based research study involved four schools representing diverse socioeconomic backgrounds, which allowed for a broad perspective on children's learning journeys. Conducting the intervention in the classroom aimed to provide an authentic learning environment for the participants. However, data collection encountered challenges due to the constraints of the classroom timetable and the teacher's responsibilities. Balancing the intervention while managing other classroom tasks led to occasional interruptions and affected the intervention's flow. Nevertheless, the study's focus on the classroom setting accurately reflected the complex nature of primary school environments, considering factors such as noise and diverse demands on teachers and students.

The researcher's involvement, intrinsic to the design-based research approach, had implications during focus group sessions. Children's awareness of being observed and recorded influenced their responses, potentially impacting the data gathered. Additionally, the novelty factor of the programmable floor robot during classroom play might have influenced initial engagement, necessitating a longer study to examine sustained interest over time.

Employing the Design-Based Research approach within the Social-Cultural Theory framework, the study acknowledged certain limitations that were consistently addressed to ensure valid findings. The smaller sample size compared to other international studies on robotics might limit the generalisability of results to the broader Computational Thinking (CT) or language learning community. However, the study effectively highlighted the simultaneous development of language and CT through a specific teaching methodology.

Although efforts were made to include diverse schools in the pilot studies and final cycle, the researcher's own school network limited the selection. Furthermore, having only one junior infant class participate in the final cycle prevented a direct comparison between classes with and without the Bee-Bot intervention. Despite these constraints, conducting the research part-time within the researcher's school network allowed for sufficient observation time in the classrooms.

During focus group interviews, the researcher's presence influenced the children's responses, with some expressing shyness and reluctance to share their opinions. Nevertheless, this limitation was mitigated by relying on video recordings to supplement the data collection process.

4.12 Conclusion

The chapter started by introducing the research questions that this study aimed to address and provided a comprehensive outline of the study's structure and design. The study's complexity arose from the incorporation of various iterations involving diverse methods and approaches. In this chapter, the conceptual framework underpinning the research was outlined, which includes the constructivist philosophy supporting a constructionist approach, as well as the integration of Design-Based Research (DBR), Child Voice, and Mixed Methods Approaches. The chapter proceeded to discuss the data collection techniques and research instruments employed in the study, followed by an initial overview of the data analysis process. Ethical considerations were also addressed, ensuring the study's adherence to ethical principles. The chapter concluded with the potential limitations impacting the study. The next chapter will outline the design process.

5 Design Process

This section presents the iterative design pilot cycles of this project (Figure 9), followed by the design objectives (section 5.1.1) of the project and the pedagogical and activity considerations for the development of the intervention. Section 5.1.1 looks at the design objectives and an overview of the iterative design cycles. Section 5.1.2 looks at the pedagogical considerations of the intervention, with play situated within the broader framework of SLL. Section 5.2.4 outlines factors that affected participation in pilot cycle 3 of this DBR study. The procedures and findings from the pilot stages are then presented in section 5.3 along with feedback from these cycles, which contributed to the final cycle of this research intervention.

5.1 Iterative Design Cycle

The DBR approach to this research intervention in Figure 9 is in line with the principles of DBR; it took the form of an iterative design processes (Figure 7). There were three pilot cycles in total and one final cycle as part of the main study. The first pilot cycle aimed to explore the assent form, pre- and post-activity questionnaires and recording devices (Table 11). The second pilot aimed to explore the design of the activity, focus group model and data collection tools: questionnaires and recording device (Table 13). The third pilot cycle aimed to investigate the role of the teacher and integrate the activity into the classroom timetable (Table 14). Throughout pilot cycles two and three, there was a focus on user consultation. The children shared their thoughts and opinions, what they liked about the activity and what they disliked about the activity during focus groups (section 5.4.2.2 and 5.4.3.1). The data collected from the pilot studies shaped and informed the design of the activity for the fourth and final cycle. The revised activity design was implemented in cycle four, and the data collected was used to address the research questions set out in section 4.2. This chapter outlines the procedures for pilot cycles one, two, and three and the findings from these pilot cycles along with theoretical contributions. Chapter 6 describes cycle four in detail. Chapters 7 and 8 present and discuss the findings from cycle four.

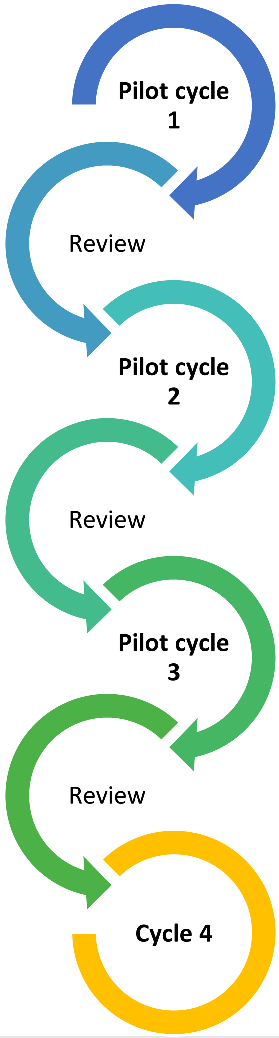


Figure 9 Design cycle of the research intervention

5.1.1 Design Objectives

The research questions for this thesis were outlined in section 4.2. As mentioned earlier, the methodology adopted for this study is Design-Based Research (DBR). DBR is distinct in its approach as it strives to create an efficient learning environment and, concurrently, utilises this environment as a means to investigate learning and teaching (Sandoval & Bell, 2004). Throughout the design process of this investigation, three overarching objectives were identified:

- To integrate a digital device into the early year's classroom during play
- To develop a learning activity that incorporated both the Irish language and CT skills
- To encourage child agency during a collaborative activity

Through the iterative cycles of the design process, as outlined above, the most appropriate and effective approaches for using the Bee-Bot during the activity were realised. Each cycle within the study provided new insight on the most effective way to integrate the activity into classroom practice and the most effective ways to gather feedback from the children and the teachers.

5.1.2 Pedagogical Approach

There were several goals that informed the choice of pedagogical approach for this research intervention. They were important to identify so that the objectives could be achieved and to create a suitable activity for exploring the research questions. The principal goals were:

1. To use a digital device to promote CT skills
2. To create an environment for enjoyable language use
3. To encourage a collaborative play activity
4. To develop a fun learning activity that children lead

In order to achieve these goals, this study looked at SCT and the methodology of play in the early year's classroom and how to integrate language learning and CT skills effectively. The methodology of guided play was chosen and will be outlined below. When choosing the pedagogical approach for this project, consideration had to be given to the constructs of SCT, second language learning and CT skills. The age group of the children and what methodologies are usually employed by the teacher were also considered. A play area for the intervention was designed in the classroom so as to address the principal goals while maintaining the children's interest in the activity. The pedagogy of guided play was chosen because of the age of the children and how the teacher could effectively demonstrate the activity and encourage the children to lead the activity afterwards.

The design of the activity followed the principles of guided play and DBR, whereby the teacher, along with the researcher, designed the setting for the activity, which highlighted the learning goal and ensured that the children had autonomy within that setting. Guided play crucially incorporates an element of adult structuring of the play environment, but the child maintains control within that environment (Weisberg, Kittredge, Hirsh-Pasek, Golinkoff, & Klahr, 2015). When the children completed their Irish language lesson as a whole class, they participated in the activity during the designated activity time in class. In the classroom, the teacher can guide play in one of two ways: by carefully preparing the classroom or play area beforehand and by scaffolding children's actions as the play unfolds over time (Fisher, Hirsh-Pasek, Golinkoff, Singer, & Berk, 2011). In this research study, we see both happen at different times during the activity. The teacher assisted the children in setting up the activity, assigning numbers for turn-taking and demonstrating how to move Bee-Bot. The teacher also reminded the children of the new language they had heard during their language lesson. The teacher transitioned thereafter to support the activity by watching the children direct the activity making comments, asking questions, and reminding the children to use their new language.

Guided play takes place in a structured classroom environment with some form of adult scaffolding, allowing a teacher's expertise to inform how children should approach the situation. Yet guided play leaves the locus of control with the child, making room for self-directed exploration (Weisberg et al., 2015).

As the teacher stepped away to support other groups, this gave the children an opportunity to fully direct the activity by themselves. During the activity, some children were identified as the "teacher" or MKO in the group through complimenting a positive outcome or assisting others when they found the task difficult.

5.2 Design approach

Throughout the DBR activity, there were a number of elements to consider during its implementation, such as the introduction of the activity, the types of tasks, the resources required classroom management and the size of the groups participating in the activity. Collaboration with the classroom teacher was central to addressing each of these considerations. Bers (2020) outlines a list of considerations when the goal of the activity is to promote CT through a playful environment.

Table 12 Seven conditions for bringing coding into the early classroom (Adapted from Bers, 2020, p.219-221)

1.	Pacing: it's important to consider the scope and sequence of activities designed to engage with the powerful ideas of computer science.
2.	Types of coding activities: some are structured challenges, while others involved free exploration.
3.	Materials: to code, we need tools. Although CT can be explored through low-tech materials such as printed icons of different programming commands of a programming language, this is no substitution for the programming language itself.
4.	Classroom management: teaching in an early childhood setting requires careful planning and ongoing adjustments when it comes to classroom management.

5.	Group sizes: as in any other kind of early childhood initiative, the experience can be whole group, small group, in pairs, or individual. Whether it is feasible depends on the availability of materials.
6.	Addressing state and national frameworks: at the time of writing, there is no national framework in Ireland that addresses CT or coding in the early years. However, schools have implemented their own projects, and the NCCA undertook a National Coding Initiative in 2019 (NCCA, 2019).
7.	Assessments: with the playground approach to coding, children certainly have fun; however, evaluating the learning process and the learning outcomes is important.

Bers (2008a, p. 12) outlines four fundamental principles to create effective constructionist learning environments that are suitable for early childhood development:

- Encouraging learning through the design of meaningful projects that can be shared within the community.
- Utilising concrete objects to facilitate hands-on exploration and understanding of the world.
- Focusing on powerful ideas that hold personal and epistemological significance.
- Incorporating self-reflection as an integral part of the learning process.

5.2.1 Overview of pilot cycles

The initial phase of the DBR process, pilot cycle one, was based on aims of the study and a review of the literature. This pilot study aimed to investigate the potential of using Bee-Bot for language learning and computational skill development with primary school children. Its primary objective was to test and refine the pedagogical approach and activity design before conducting two more pilot cycles, which would contribute to further enhancing the research design.

During the pilot cycles, the research was conducted in three schools located in Dublin. School one and two were urban middle-class schools, while school three was an inner-city DEIS school (Education, 2020). However, school three presented certain challenges for the study. The classroom in school three consisted of children with diverse additional needs, which affected the implementation of the activity during this cycle. At the beginning of the school year, the teacher and the class were still establishing classroom routines, which further complicated the implementation process. The recording of the activity, the design of the activity, scaffolding the children, and data collection were impacted by these challenges. The teacher was unable to implement the activity on a daily basis due to the circumstances in the class. Moreover, the children in school three had their regular classroom timetable, as well as a timetable with a support teacher for Maths and English. As a result, they couldn't always participate in their Irish language lessons or in the research activity, which posed limitations during the pilot cycle and informed the subsequent main cycle. This situation shed light on the importance of considering the classroom timetable and the need for consistency when introducing new language and skills to children. This reality of the classroom timetable was an important factor that influenced the overall study and its findings.

The pilot cycles were conducted to assess the suitability of the research instruments for use in the main research cycle. This section outlines the procedures followed during the pilot cycles and provides a summary of the participants' responses to the activity. It also includes an evaluation of the activity design, the intervention, and the research instruments, along with any necessary changes for improvement in subsequent cycles. Pilot cycles one and two were conducted as one-day cycles, primarily to test the research instruments and the initial activity design. This step was crucial in ensuring the effectiveness of data collection and refining the activity design to suit the age group of the children.

5.2.2 Pilot cycle one

Table 13 Pilot cycle one procedures

Pilot cycle 1	
Participants	27 boys in Senior Infants in mixed ability groups aged 6-7 years
Venue	Corner of the classroom
Duration	150 minutes total 20 minutes for questionnaire and assent (pre-activity) Five groups X 20 minutes for the activity 20 minutes for the post activity questionnaire
Pedagogical Approach	Direct instruction

	Guided Play – Teacher designed activity, modelling scaffolding, questioning	
Technological Approach	Interactive Whiteboard Interactive Games Bee-Bot	
Research Instruments (for piloting and data collection)	Assent form Questionnaires Activity recordings Teacher interview (See chapter 4)	

Two weeks prior to the pilot, the teacher conducted computational thinking unplugged activities, where the children practiced using directional language in Irish. The purpose of these unplugged activities was to introduce directional language into the classroom and ensure that the children were comfortable using it prior to commencing the Bee-Bot activity. To begin, the teacher modelled the process and used visual aids to give directions for moving an object on a mat or to direct one of the children around the room. The teacher used a direct teaching method to demonstrate these activities to the children. This would provide foundational directional to the children for when they participated in the activity with the robot. During the two-week period before the intervention, when the children were learning directional language in Irish through unplugged activities, they engaged in programming each other around the classroom, simulating the role of robots. This activity piqued the children's interest, and they enjoyed directing each other and their teacher around the room. The teacher, during her interview after pilot cycle one, commented:

> *The biggest challenge at the start was to really identify left from right even, you know, whether it was in Irish or in English to just know your left from your right, so that was probably, you know, the challenge. The first few days, I just gave an instruction, and the whole class just followed it…...and then soon I could see there are really eager to kind of progress with it. And so, I started getting them to direct each other, so somebody would get up, and then somebody else would direct them to say from their seat, maybe around another table and somewhere in the room, and they thought it was so much fun and, you know, really got a lot of stimulation out of it, so they loved it.*

Teacher Pilot cycle 1.

The children also played tabletop games as a group. The mat on which they played the game reflected that of the Bee-Bot activity. They used directional cards and a small teddy like figure to play this game. One child gave instructions and played out the cards, and the other followed the instructions by physically moving the teddy figure. The teacher was able to monitor the children as a class while they played these games and support them when necessary.

On the morning of the pilot study, the children undertook an assent form and a questionnaire. Of 27, one child from the class responded no to participating in the activity, five children responded no to the camera recording them, and seven children responded no to talking to the researcher or their teacher about the activity. All necessary arrangements were made for these children, as mentioned in section 4. The classroom teacher commented on the assent process and the limitations of it with this age group.

> *Yeah, I thought that was really worthwhile, and you know it was really interesting to see the way some of the boys because obviously, I've taught them for a year and a half, so I know them quite well, so even a glancing around, you could see boys that were really engaging with what you're asking of them, and then you've other boys that are maybe quite unsure and maybe just looking to see what somebody else is filling in or what they think may be potentially the cool answer to fill in is, and you know one boy was like shouting to another boy at another table saying what did you put in for that.*

Teacher Pilot cycle 1

5.2.2.1 Questionnaires

Consent had been gathered prior to the researcher's arrival. The focus for pilot cycle one was to test the assent form, the questionnaires and how useful the recordings of the activity were. A significant amount of time was given to the questionnaire at the start of the day to ensure that children understood the language. Where confusion arose or when the teacher or the researcher were asked to provide clarification, a note was made of the language that the children were struggling with. What became apparent about this age group was that additional explanation was needed beyond the questionnaire. The study utilised a questionnaire consisting of statements for children to respond to with a "yes" or "no" answer format (section 4.8.2). Due to the age of the cohort, a list of statements was considered more suitable for the questionnaire format.The children were asked to answer yes or no to five statements. They were asked if they liked learning Irish, pre-activity the response was 18/27, with the post-activity response of 20/27. The children were asked about having chances or opportunities to use their Irish in school or at home. The additional descriptor was given by the researcher when administering the questionnaire alongside the classroom teacher as the use of the word “chance” needed clarification. There was an increase of 6 from the pre and post questionnaire for this question as children recognised the use of the Irish language within the activity as a chance or opportunity to use it. In question four, the children were asked do they use technology in the classroom; the children questioned the word technology. Some identified the teacher’s desktop computer and classroom iPad as technology; most of the children did not identify the overhead projector as a piece of technology even though the classroom teacher used it every day in the delivery of the lessons. Post activity, the children saw Bee-Bot as a piece of technology within the classroom. There was an increase of one for the post activity for this question. The table below shows the answers before the activity in blue and post-activity in orange.

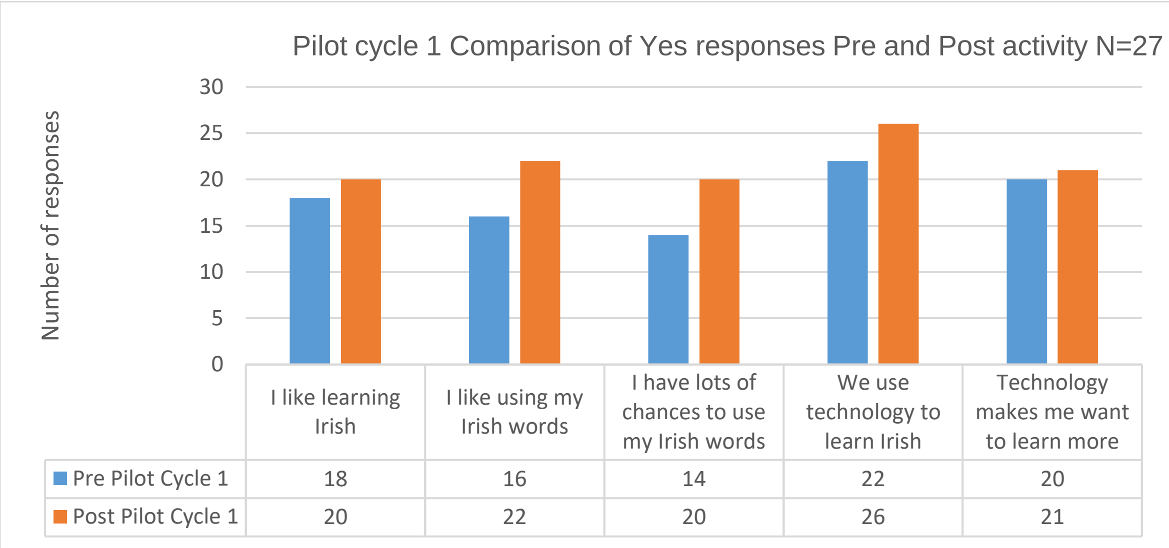
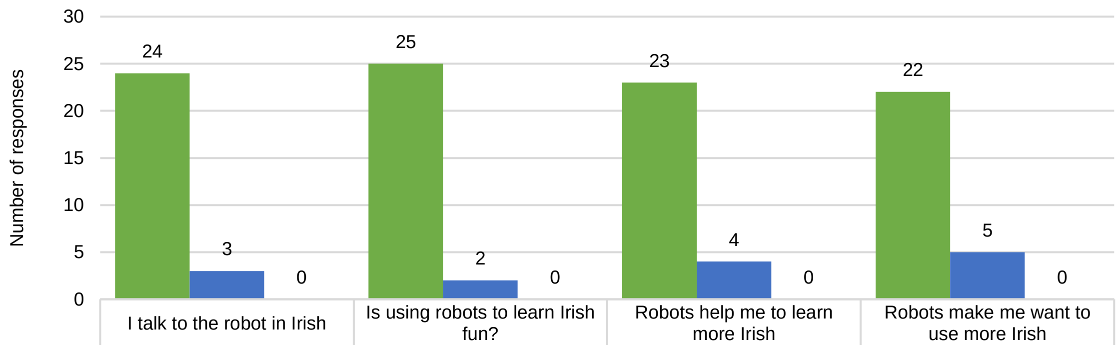


Figure 10 Pilot cycle 1 Comparison of Yes responses Pre and Post activity

There were an additional four questions on the post activity questionnaire. Again, these were phrased as statements, and the children answered yes or no. The focus of these questions was on Bee-Bot and using Irish. A majority of the children, 24/27, responded yes to talking to Bee-Bot in Irish. This was an indicator that the children see Bee-Bot as a device they use in Irish. A majority of the class thought it was fun using robots to learn Irish; 23 children responded yes to robots help them learn more Irish, and 22 children said yes to robots encouraging them to use more Irish. There was no option during this pilot to ask the children further questions about the responses as focus groups were not a focus for this pilot cycle.



	I talk to the robot in Irish	Is using robots to learn Irish fun?	Robots help me to learn more Irish	Robots make me want to use more Irish
Yes	24	25	23	22
No	3	2	4	5
Maybe	0	0	0	0

Figure 11 Pilot cycle 1 Post-Intervention Questionnaire

The limitations of the questionnaire became apparent during this cycle. Some of the children had commented during the pre- and post-activity questionnaire that they weren't sure or used the word maybe as their response, but this option was not available to them. The children were encouraged to add an additional box with the answer of maybe if that was how they chose to answer. Table 12 shows one child's insertion of a maybe answer. When discussing this with the teacher during her interview, she commented that the children had participated in a Social, Personal and Health Education (SPHE) questionnaire the week before and that this was perhaps the reason the children were informed on how to answer a questionnaire. This limitation was noted, and the questionnaire was amended to include a maybe response for pilot cycle 2.

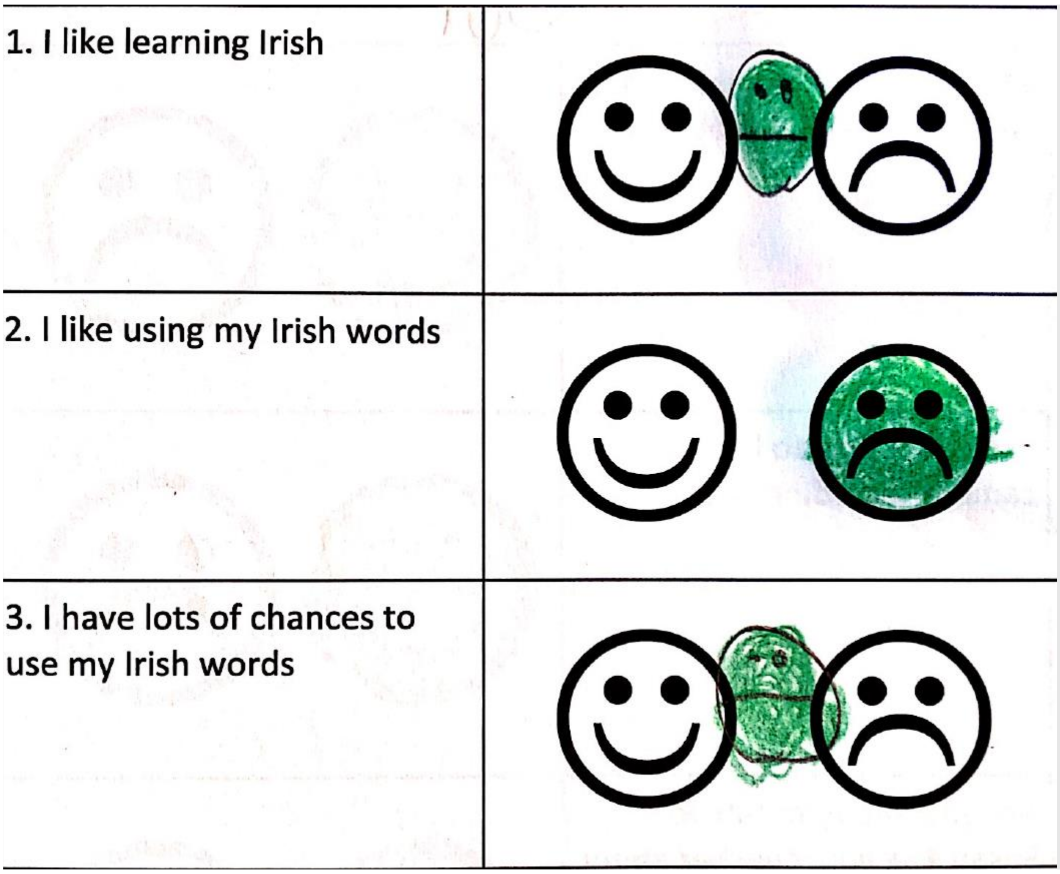


Figure 12 Questionnaire sample pilot cycle one

5.2.2.2 Teacher's response

At the end of the pilot cycle, one of the teachers participated in an interview about the research activity. The teacher had never used a Bee-Bot in her practice, and so this was all new to her. From the outset, the teacher was very positive in introducing the unplugged activities to the children and could envisage their benefit across language and Mathematics. The children were counting and learning the directional language, which linked with the maths curriculum being taught in the class. During the pilot study, the teacher participated in the group activity with the children and the researcher. The teacher commented on the positive impact the activity had on some of the children.

> *He was so positive to the whole thing and really motivated, and even today, his behaviour and everything would have been like a lot calmer than you normally would be a lot more focused. And he kept talking afterwards about how great it was, and he filled in his form afterwards, and that was all smiley face everything, and it was funny because when you ask them, pre-using the Bee-Bots his attitude to Irish everything was poor poor poor, and then afterwards it was all great. And now, like when you put it* (the activity) *altogether, I just*

saw it completely different. I could see how it could be beneficial for him in so many ways with different topics.

The teacher in cycle one also commented on how effective Bee-Bot would be with other curricular areas and when a routine was established it was only a case of changing the floor mat that Bee-Bot moved across.

"I could see myself being able to cover loads of topics and loads of language. I just thought that they were really motivated. I don't see their motivation dwindling that quickly, I would imagine, you could get a long time out of them [Bee-Bots], and they would still be highly motivated and then obviously because you can change the language on the maps that you're using."

5.2.3 Pilot cycle two

Table 14 Pilot cycle two procedures

Pilot Cycle 2	
Participants	21 girls in Senior Infants in mixed ability groups aged 6-7 years
Venue	Corner of the classroom
Duration	200 minutes 20 minutes for questionnaire and assent Five groups X 20 minutes for the activity Five groups X 10 minutes for focus group 20 minutes for the questionnaire
Pedagogical Approach	Direct instruction Guided Play – Teacher designed activity, modelling scaffolding, questioning
Technological Approach	Interactive Whiteboard Interactive Games Bee-Bot

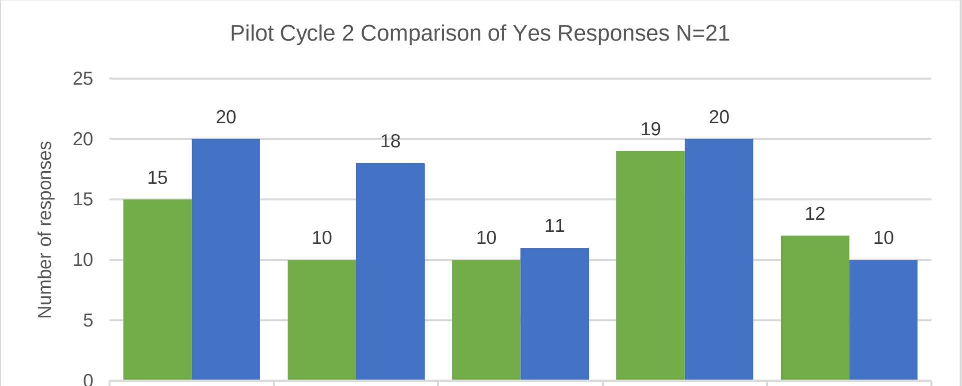
Research Instruments (for piloting and data collection)	Assent form Questionnaires before and after activity (See section 4) Activity recordings Focus group recordings

Pilot cycle two built on the data collection instruments from pilot cycle one. The central focus for cycle two was the activity recordings and the focus group recordings. The organisation of the activity and the focus group environment were also considered, along with the questions asked during the focus group. Pilot cycle 2 took place in a girl's primary school. The reason this school was selected was due to the fact that the school in the first cycle was a boy's school. While a comparative study on gender difference was a possibility between these two cycles, it was not within the scope of this study. Similar to cycle one, the children completed the assent form at the start of the day and the pre- and post-activity questionnaire. There were not as many questions this time with regard to the language used in the questionnaire as it had been reviewed and slightly altered. Similar to cycle one, an additional explanation was required as the researcher read the questions allowed. Due to time constraints, there were two groups out of five that were not recorded but did participate in the activity. One of these groups did not have consent to participate in video recordings but did have assent to participate in the activity.

The children in this cycle had two weeks of unplugged activities in the classroom. The teacher implemented these activities on a daily basis over the two weeks. There were tabletop games available to the children as well (similar to cycle 1). According to the teacher, these activities helped the children to establish the language used in the activity, which made the activity move forward more freely during the pilot.

5.2.3.1 Questionnaires

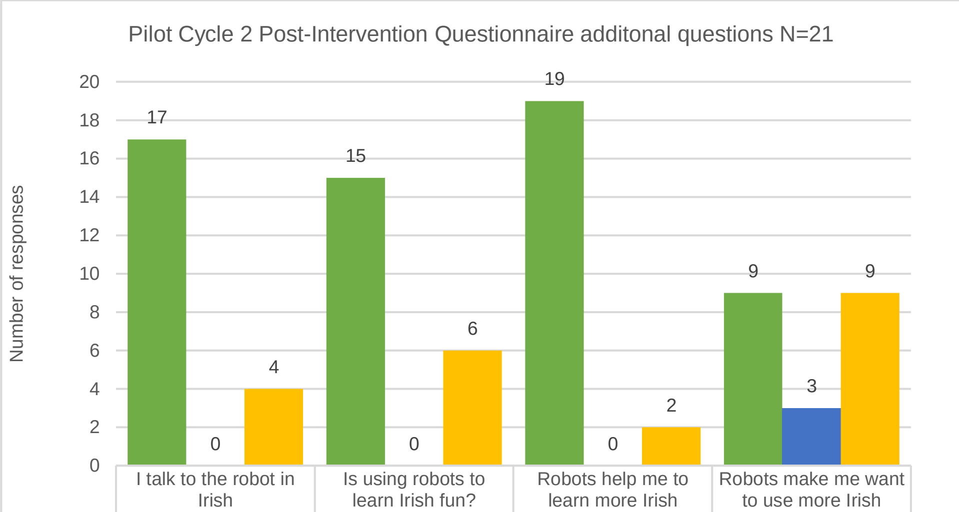
The pre- and post-activity questionnaire was amended for this cycle to include a "maybe" answer. As mentioned previously, it was a limitation of the questionnaire in cycle one. The "maybe" answer was displayed on the questionnaire by a face with no expression. In the comparison of yes answers from the pre- and post-activity questionnaire, we can see an incremental increase in positive yes responses except for the last question, which had a slight decrease (Technology makes me want to learn more). Similar to the first pilot cycle, the word technology was a challenge for the children. In this cycle, the children didn't identify the Bee-Bot is a piece of technology. They viewed the computer and the interactive whiteboard as technology, but an iPad, tablets and Bee-Bot were not. This is presented an interesting perspective on how we classify different technology tools in the classroom.



	I like learning Irish	I like using my Irish words	I have lots of chances to use my Irish words	We use technology to learn Irish	Technology makes me want to learn more
Pre	15	10	10	19	12
Post	20	18	11	20	10

Figure 10 Pilot Cycle 2 Comparison of Yes Responses Pre and Post Intervention

The additional questions from the post activity questionnaire are highlighted below. During this cycle, 17/21 children identified the Bee-Bot as a robot they spoke to in Irish while four children said maybe, 15 children said yes that this activity was a fun way to learn Irish and robots helped them learn Irish. The final question of "Robots make me want to use more Irish," saw a balance between yes and maybe answers. The word *"use"* in this question was a challenge for the children. They questioned the researcher during the delivery of the question to what was meant by "*use."* While the children could identify that they use a pencil to write and a chair to sit on, language didn't seem like something you use; it just happened.



	I talk to the robot in Irish	Is using robots to learn Irish fun?	Robots help me to learn more Irish	Robots make me want to use more Irish
Yes	17	15	19	9
No	0	0	0	3
Maybe	4	6	2	9

Figure 11 Pilot Cycle 2 Additional questions post activity

5.2.3.2 Focus groups

Due to time constraints and the class schedule, three groups in total were taken for the research activity, and two groups participated in the focus group. Background noise in the classroom can be heard during the recordings, but it did not impact the recordings. The directions the children gave Bee-Bot can clearly be identified. Some of the children were excited about being on camera and spoke directly to the camera. This was to be expected as it was new and different. During the activity, the children were confident in their language use and enjoyed the activity. They commented positively during the activity on Bee-Bot and were able to identify the different pictures in Irish on the mat that related to their Irish language lessons. The pictures supported the children as the researcher asked questions; they pointed to the pictures to assist them in answering. The focus group, which followed the activity towards the end of the school day, provided additional insight on the children's views of language and how beneficial they thought the activity was. The transcript from the focus group was reviewed a number of times for emerging themes and applying Clarke and Braun (2013) six phases of analysis. Through this analysis of the data, four themes became apparent to the researcher: activity content, Irish, the assent process and learning.

The children in this class were articulate and comfortable with relaying their thoughts and opinions on the activity. When asked about unplugged activities and whether they thought that they were easy or not, the children identified their teacher as their support and someone that could assist them during the activity. The children recognised their teacher helping or scaffolding them as part of the learning process and that through practice and repetition, the activity would get easier. One of the children commented:

Well, em our teacher helped us a lot and said them before we said them. So, if we get it wrong, then she tells us to turn the other way. So, every single day getting even better, but I think today was very good day.

As part of ensuring that the children's voice was heard, it was important to inform the children about the activity and gain their assent to record them and discuss the activity with them. The children in pilot cycle two were asked about the process of giving assent. Some of the children spoke about the mention of the camera during the assent questions and how they felt scared about this. When they saw the small camera, they felt more comfortable doing the activity, but this was a point of acknowledgement for the researcher to ensure that the children could see the data collection tool during the assent process. When the children were asked about participating in the assent process, one child commented that their “moms” were normally asked. When questioned further on whether they thought it was important, they were asked one child commented:

So, we would. So, if we were if we were doing it and we didn't know, and maybe we didn't want to.

Another child commented:

If we like if our parents didn’t to tell us, like, and we weren't sure if we wanted to do it or not, if they didn't tell us we would be surprised when we got in and didn’t know what was going on.

There were a number of comments of a similar nature to these within the two groups who participated in the focus groups. These are significant observations from this group of young children. Their observations are supported by the literature, which both acknowledges and supports the importance of informed assent from children, including young children. The children participating in the research project felt they were informed about the project, and they felt more comfortable about the choices they were making.

The children’s feedback on the design of the activity came up as they were being asked about using Irish. Feedback on the design of the activity is important to the DBR cycle and for further development of the activity and resources. The design of the floor mat on the day of the pilot cycle 2 had Teddy doing lots actions and activities. The children were familiar with the Irish language associated with each of the activities Teddy was doing on the mat. The children really enjoyed using the Teddy mat as it was very familiar, and they had a song they could sing together for each picture. One of the children commented how they preferred this mat to the mat they had been using that had shapes on it. While the children found the Teddy mat “more fun.” They compared the Bee-Bot activity to other activities that take place in the classroom at the same time. While it is natural to prefer some activities over others, the children were asked about using Irish in the other activities during their play session. One child commented that they don't use Irish in other activities, only during Bee-Bot. As the children discussed using the Irish language for programming Bee-Bot, one of the children highlighted how some of the children said the instructions out loud while others didn't and how the teacher helping them makes it easier.

> *CH4: Yeah, some people kind of like use, what, which way they're gonna do in their head, and sometimes they don't actually tell us they do, like, in their head, but most of the people, just do it in their head.*

Chapter 4 raised an intriguing observation: while engaging in the activity, the majority of the children mentally process the actions, with some silently contemplating the steps, while others verbalise the directions aloud. This observation aligns with the video recordings, where certain children in the group were observed programming Bee-Bot silently yet successfully reaching the desired destination. In contrast, some children utilised the mat and verbalised the directions to externalise their thoughts, relying on others as a scaffold to support their understanding. CH4 further identified that certain children exhibited algorithmic thinking in two distinct ways during the activity.

5.2.4 Pilot cycle three

Table 14 Pilot cycle three procedures

Pilot cycle 3	
Participants	24 children (boys and girls) in Senior Infants in mixed ability groups aged 6-7 years
Venue	Classroom (Section of the classroom)
Duration	Six weeks + 2 weeks of unplugged activities (8 total) One hour of play activities per day, children rotate between 4 activities. They visit the Bee-Bot activity for 12 minutes approx.
Pedagogical Approach	Direct instruction Guided Play – Teacher designed activity, modelling scaffolding, questioning
Technological Approach	Interactive Whiteboard Interactive Games

	Bee-Bot
Research Instruments (for piloting and data collection)	Assent form Questionnaires before and after activity (See section 4) Activity recordings Teacher's reflective diary Focus group recordings

Pilot cycle 3 took place in a co-educational school. After piloting in a boy's school and a girl's school, it was important to balance the approach of the DBR cycles with a co-educational setting. The children in this group all assented to the activity, and consent was received from their parents. The children participated in the pre-activity questionnaire but did not participate in the post-activity questionnaire. This was due to a number of reasons which will be elaborated on below.

Pilot cycle three was six weeks in length to fully trial the research activity and integrate it into classroom schedule. As in previous cycles, the teacher was given a set of resources so the children could participate in unplugged activities. As the research activity was scheduled to run for six weeks prior to the autumn school break, it was difficult for the classroom teacher to fully implement the unplugged activities into the classroom schedule. The children were settling into a new classroom, with a new teacher and a new classroom timetable. The children experienced the unplugged activities whenever there was time available, but they found directional language in Irish challenging. The researcher and the teacher reflected on this and whether or not to continue with the cycle. The previous two cycles had informed the study that the children knowing the directional prior to participating in the activity made it much easier for them to participate in the research activity. However, the classroom teacher was very enthusiastic and confident that when the activity was integrated into the classroom routine, it would be a success. The teacher and the researcher decided together to progress with the research activity. The classroom activities were scheduled to take place over an hour each day where the children rotated from one activity to the next every 15 minutes with a bell sounding for when they had to move. The previous cycles saw the children do the activity over a 20–25-minute period. Aligning with the DBR approach the research activity adapted to suit the classroom environment. The teacher in cycle 3 highlighted how she would have to monitor the other groups also but would do a full class activity on how to use Bee-Bot so that all children were informed before moving to their small groups. When the children were in their activity rotation, the teacher planned to assist the children in the setup and then monitor the other groups.

The cycle commenced in late October, and the researcher attended the school over the first week to ensure the teacher was comfortable with the camera setup for the recordings and finding the best space for the activity. A number of different scenarios arose in the classroom during this cycle which the researcher and the teacher had to adapt to as is the nature of a DBR study. Across all activities in the classroom, the children needed assistance and scaffolding from the teacher. This presented a challenge for the teacher when it came to monitoring the Bee-Bot activity and recording the sessions. The Bee-Bot activity was a new activity for the children and the teacher was restricted in the time she could attend to the group as other groups also required support. While the teacher distributed her support to other groups as is the case in infant classrooms the research activity did run as initially set out by the researcher and the classroom teacher. Ten videos were returned in total, with only six videos for review due to no sound or the camera facing the wrong way. While six videos were available for review, the children inputting codes into Bee-Bot could not be seen due to the camera angle.

While researcher and the teacher had weekly meetings to review the activity and how it was progressing the classroom teacher remained positive and viewed the next week as a fresh start at the research activity. After week three, the classroom routine changed, and the children had limited time to participate in the activity. Again, there was consideration given to cancelling the rest of the cycle after week three due to the children not having the opportunity to do the activity as some of the children were challenging to manage in the classroom. The teacher maintained positive outlook and was happy that things would improve due to additional supports that were being provided to the class for some of the children. The support was provided by two Special Education Needs Assistants and additional Special Education Teaching hours. The cycle continued for another three weeks; however, there was little opportunity for the teacher and the children to carry out the activity as set out initially due to behavioural issues and a challenging timetable. In response to behavioural issues, the classroom schedule was changed regularly, with support teachers coming into the class to help. This had an impact on every aspect of the classroom timetable, including Irish. There was little time for the research project, which the researcher completely understood as the children and their learning and comfort in the classroom was the priority. While the research activity didn’t go as it was initially planned, the children can be observed in the ten videos returned to the researcher enjoying their time playing with Bee-Bot.

5.2.4.1 Focus groups

The focus group for this cycle was the main source of feedback from the children on the activity. The researcher visited the classroom at the end of week six to complete the focus groups with the children. Thematic analysis was not carried out on these focus groups as the children had not engaged with the research activity consistently over six weeks. However, the children did have time to play with Bee-Bot and the opinions on the robot were considered. The researcher organised the focus groups according to the classroom activity groups. That meant that the groups who normally played with Bee-Bot together could discuss it together. The children were distracted by the camera and found it challenging to focus on the question being asked about the activity. The groups were between 4-6 children. They gave positive reviews on the time they spent playing with Bee-Bot. They liked Bee-Bot, and they enjoyed the noises he made.

> *CHI: Because I liked the way they moved. Gzzzed (making sounds and gesturing with hands) I like the noise of them* (Bee-Bot) *when they move. Gzzzed gzzzed.*

When it came to turn-taking during the activity, the majority of children commented they did not enjoy waiting their turn for Bee-Bot. They commented that they felt angry while they waited. This corresponds with the teacher's report on the activity where she had to manage their behaviour and that the turn-taking cycle was challenging for the children. The children commented during the focus group that they were using Bee-Bot to learn Irish. When asked about the language they were learning, most of the children paused in silence and found it difficult to recall the words where others called out the different items they remembered from the mat. When questioned about the mat's design, the children recalled using various mats with Bee-Bot in the past, each featuring different designs. One child mentioned using a mat-based on space. The children were asked about Bee-Bot and the design of Bee-Bot. The children mentioned that they wished he could talk and how sometimes he went the wrong way. They did know that it was not Bee-Bot that necessarily went the wrong way, but the code that was inputted by them sent him the wrong way.

> *CHI: Sometimes we forget to press x, and then we press that way, and it goes front (pointing)*

5.2.4.2 Teacher's response

After the six-week cycle, the researcher sat with the classroom teacher to discuss the activity extensively. The teacher remained positive about the activity but had some interesting observations to make about the design of the activity, which contributed to the DBR process. The teacher felt that the Bee-Bot activity for her "*lacked focus*," and the children didn't know *"what the point of it was."* While the mat the children used for the Bee-Bot activity had the Irish words which related to the Irish lesson on it, there was no clear direction in her opinion. Instead, the children picked a destination and sent the Bee-Bot there. This worked initially, and the child who was coding the Bee-Bot at the time enjoyed it, the other children in the group tended to lose interest, or they wanted to have a turn.

The mat that the children were using for the activity was updated in line with the themes the children were learning in Irish however they often did not have a do their daily Irish lesson, and so they didn't couldn't identify the pictures on the mat in Irish. Behaviour management, literacy, and numeracy according to the teacher took priority over Irish. This had been established as the school's focus for the class. When the children did attend the Bee-Bot activity, they identified the words and moved Bee-Bot from one picture to the next. The teacher highlighted there was no story or, in effect, goal to achieve by doing this. The teacher remained positive about the use of Bee-Bots and commented that she would continue to integrate the Bee-Bot during activity time in the class. She also mentioned how useful the Bee-Bots would be across many different subject areas. She ran an after-school club and was considering integrating them into different friendship groups in the after-school club.

5.3 Findings and theoretical contribution

Prior to the commencement of the final DBR cycle, the issues which arose during the pilot cycles were acknowledged. While the general design and integration of the activity worked well; the teacher needed to have more time with the group to support them in their learning. The children across all pilot cycles enjoyed the activity and enjoyed participating in the activity in a group. The wait time for turn-taking did frustrate some children, which was a reflection of the size of the groups. The time spent with the activity also impacted on the number of opportunities the children had to use Bee-Bot. A rotation every 15 was considered to be too distracting for the children. The need for a continuous daily intervention for effective integration of the activity was identified during pilot cycle three; however, it did show that the need for teacher interaction and scaffolding during the activity was needed for it to progress effectively. The majority of language used was English which was not surprising for this age group and for the time allocated daily to the Irish language. However, the Irish language topics covered were reflected on the Bee-Bot mat, and the children did use their new language during the pilot cycles, even if it was a mixture of L1 and L2. By adding a purpose or a narrative, which was a significant outcome from cycle 3, to the activity for the next cycle, would offer the children an opportunity to extend their language use from one-word utterances to sentences. The questionnaire used in the pilot cycle underwent modifications after pilot cycle one, and it was found suitable for continuation in cycle 4. It was intended that pilot cycle three would offer a deeper insight into SCT constructs that arose during the activity and computational skill development, due to the lack of video data, this was not possible. Before moving forward to cycle four, the setup of the camera and the area in which recording would take place in the classroom was considered so as to avoid this issue. A longer period of time with the classroom teacher would be needed prior to the commencement of cycle 4, which would include short trials of the setup and recording.

The core of DBR lies in how each successive cycle contributed to the evolution of the research's theoretical foundation. This was achieved through the continuous development and improvement of data collection tools and activity design. An interesting question arose from the pilot cycles: *what level of support do the children need for the activity to be effective?* From the consultation with the users and an analysis of the data collected over the three pilot cycles, three areas were highlighted in terms of the conditions that were needed for the activity to have more of an impact during the pilot cycles. They were daily Irish language lessons; time; and teacher input into the activity and the purpose of the activity. In preparation for the activity, the researcher and each classroom teacher discussed the time commitment and organisation of the activity. During pilot cycle one and pilot cycle two, the unplugged activities were carried out by the classroom teacher and the intervention activity over one day was carried out by the researcher. Pilot cycle three was carried out by the classroom teacher with one weekly visit from the researcher over an eight-week period which included two weeks for unplugged activities. The children during pilots one and two were familiar with directional language in Irish and how to use the Bee-Bot, however, the focus of the activity and the Irish language, which was reflected by pictures on the mat, was not always familiar to them. The teachers during their interview with the researcher noted that while they used informal Irish throughout the day, they regularly did not get an opportunity to teach their Irish language lesson due to timetabling pressures. Instead, they sang songs in Irish and played games rather than teach the language which related with a topic or a theme. During cycle 3, the children were not learning or revising the target language regularly in class and they found it difficult to recall the language during the Bee-Bot activity. This highlighted the importance of maintaining consistency in the language lessons to thoroughly assess language development during the activity.

5.4 Conclusion

This chapter provided a comprehensive overview of the research project's design process. It began by discussing the design objectives and pedagogical approach, followed by a detailed account of the three Design-Based Research (DBR) pilot cycles and the user consultations related to the study. The influence of these processes on the design and development of the intervention in cycle four was also highlighted, along with a theoretical contribution resulting from the pedagogical research.

The three pilot cycles differed in duration, with the initial two pilots lasting one day each, and the third pilot extending to six weeks. These pilots served to assess and refine the intervention's design in preparation for cycle four, where the research questions outlined in section 4.1 were explored. Chapter 6 will delve into the design of cycle four, while chapter 7 will present the results obtained from this cycle.

6 Cycle four

The fourth and final cycle of this design-based research project took place in a junior infant classroom between January and February midterm break over six weeks. The timing of this cycle is relevant, as the children in the class had been learning Irish for only four months between September and December. Their classroom teacher agreed to participate in this research project in November, and she began to prepare the children for the activity from the second week in December. The preparation included unplugged activities where the children familiarised themselves with directional language in Irish and played games using this language. After spending some time exploring the directional language with the children as a group, the teacher set up tabletop activities for the children where they directed each other and their chosen characters around a board game mat. Their characters were usually a small toy from the classroom dollhouse, or a small teddy used for numeracy games. An additional activity included directing each other around the room imagining they were robots. An overview of the study is available below (Table 15).

Table 15 Overview of cycle four

	Cycle four: main study (2 weeks of unplugged activities+ 6 week activity post Christmas break)
Details	• Language lesson taught by the teacher • Small group activities (free writing table, sand, constructions etc.) focused on language lesson one to be robotics activity • Children move daily from one activity to the next. Each activity is 20-30 minutes in duration (6 weeks x 4 recordings per week, 1 group did not have consent they did Bee-Bot on the 5th day) • Children were recorded at the robotics activity • Participants (Junior Infants, 27 total 22 participated, age 5-6years, Co-educational)
Overview	The children participated in a robotics activity during Play with a focus on the target from their Irish language lesson. The teacher, through guided play, scaffolded the children's learning and stayed with the children at the activity for a minimum of 10 minutes.
Objectives	• Run the activity over a 6-week period • Gather feedback from the children and the teacher on the design of the activity and its effectiveness. • Address the research questions of the study.
Research design	• Exploratory study • Focus on the children's development through the SCT framework of analysis. • Focus on the children's use of the CT skills framework (Angeli et al., 2016) . • Focus on the social, target and directional language used during the activity.

Data collection	• 22 pre-and post-intervention questionnaires • Video recordings • Photographs • Children's focus group • Teacher interview • Teacher's reflective journal • Children's drawings

The data collection instruments for the study are outlined in section 4.8. In this research study, the most important source of data was the recordings of the Bee-Bot activity sessions and the written transcriptions of those sessions. The video recordings of the children's interactions were recorded every time they participated in the activity on a small camera that sat on a tripod in front of the group. There were four groups in total that had consent to participate in the activity. One group did not have consent for the recording, and so they participated in the activity without the camera.

6.1 Pedagogical considerations

The layout of the activity in the classroom environment can be viewed in Appendix I. The teacher set the activity to the front of the room, as some children did not have permission to appear on camera. Behind the camera, all other children could continue with their assigned play activity for the day without appearing on camera. While this worked effectively for capturing the activity, it is evident from the recordings that there was a challenge for the teacher in guiding the Bee-Bot activity while also assisting the other children when they had questions relating to their own activities. At times, the teacher had to step away from the Bee-Bot activity to assist others. This did eventually become part of the activity so that the children could gain more ownership over the activity and help each other; however, at the start, it left the children in a position where they did not carry on with the activity without the teacher or one member of the group dominated the activity entirely.

6.2 School Selection

As discussed in section 4, schools were selected from the researcher's locality and network. For practical reasons, it is not always possible to employ random sampling for second language learning or educational research. Participants are usually in pre-existing groups, such as classes in primary schools. Therefore, it is not always possible to set up authentic experimental conditions when exploring language learning in a school setting. For school-based research, school environments may vary according to whether they are urban/rural, co-educational/single-gender and disadvantaged/non-disadvantaged, and differences between classes within schools and individuals within a class. For this cycle, one class participated, and there was no control group. A school from the researcher's network was invited to participate in the study. The research project was a classroom-based intervention, and therefore full participation was required from the classroom teacher to integrate and implement the activity into the classroom schedule.

There were no technological requirements for the cycle as the researcher would provide the Bee-Bot and any additional resources required for the unplugged activities and the relevant floor mats for Bee-Bot. A co-educational school within the researcher's school network was approached and agreed to participate in the six-week research project. Through a conversation with the school principal, the requirements of the study were established, and a further conversation took place with the classroom teacher. The conditions discussed with the principal and the teacher was:

1. Openness to engage with the researcher on the development of the classroom activity
2. Support the integration of the activity through the use of the Irish language
3. Permit the researcher to visit on a weekly basis to discuss the activity and revise its effectiveness.

The principal and Board of Management approved the project, and correspondence with the school continued through the classroom teacher.

6.3 Duration

Educational intervention research tends to show a preference for shorter interventions. Dörnyei (1995) observed that in four selected educational psychology journals, 26% of interventions lasted longer than one day. However, by 2004, this percentage decreased to 16% (Dörnyei, p. 119). A similar trend is evident in the field of Second Language Acquisition (SLA). In a meta-analysis of L2 instructional effectiveness research, Norris and Ortega (2000) reported that the average duration of interventions was approximately 4 hours. Classroom-based language classes are often one hour long, and in a university setting, there might be one class per week. Consequently, some interventions in academic environments may extend over a longer period of time due to the inherent structure of the learning setting.

In this particular study, the duration of the research intervention was guided by practical considerations. The intervention took place over a six-week period, with the number of sessions per week decided in collaboration with the class teacher. Each session lasted between 15 to 30 minutes. Initially, the teacher provided additional support to the children during their first turn with Bee-Bot and allowed them to explore independently afterward while monitoring their progress. Over time, the need for extra support diminished.

6.4 Data collection and analysis

The data collection instruments were described in section 4.8. Some specific additional details relating to cycle four are given below. There were 19 recordings of the activity in total ranging from 15-30 minutes (sample transcripts Appendix K and L). The recordings were filed according to the day and the group's name (1. Orange Group) and transcribed using the CHILDES transcription software. A code was assigned to each child for anonymity (Orange group child 1 = OC1), and where the children call out each other's names in the activity, their names were removed and replaced with their assigned code. Transcriptions of recordings can be "*fraught with slippage; it is dependent on the knowledge and skill of the transcribing person*" (Miles, Huberman, & Saldaña, 2018, p. 71). Noise interference presented an issue at times as the children spoke over and background noise can be heard from the other activities, through repeated observations of the recordings, the researcher was able to establish what was being said. As outlined in section 4.9.3 actions were also recorded as the children made gestures to elaborate on what they were saying; when they input instructions into Bee-Bot; and when they were assisting each other. All of these physical movements are relevant in highlighting sociocultural constructs during the activity, enjoyment of the activity and their comprehension of the activity. The number of recordings per group varied; there were additional recordings for some groups and a reduced number for others. This was due to the teachers scheduling of the activity. There are some children absent from videos, and some children swapped groups. The class group had chickenpox during the research activity, and there where are a number of children absent across three weeks. The teacher assigned different children to different groups so that they would not miss the activity. A log was kept of the children who moved between groups. The corpuses logged from each group for each session are shown in Table 6 in section 4.9.3. The total corpus length was 27,788 words.

Table 15 Transcriptions of activity retrieved for each group

Day	1	2	3	4	5
Orange	✓	✓	✓	✓	✓
Green	✓	✓	✓	✓	✓

Yellow	✓	✓	✓	✓	×
Purple	✓	✓	✓	×	×

The focus group interviews were recorded, transcribed, and analysed, following the procedures outlined in section 4.7.3. The approach to the focus groups in cycle 4 was amended from the previous cycle. Video-stimulated recordings were used to support the children's conversations during the focus group (Theobald, 2012). During the focus groups the children watched short clips of the recordings of the activity. They were invited to discuss what was happening in the activity as highlighted in section 4.8.5. The use of VSRs was an adjustment in the research design to support the children in relaying their perspectives. The video clips were used to remind the children of what happened during the activity; explain what was going on; discuss what they were doing; interpret what the other children and their teacher were doing. The children were asked open-ended questions to encourage them to go deeper into the conversation. The conversations with the children were between 5 to 20 minutes.

The day the focus groups were scheduled to take place in the class, there was a whole school puppet theatre event scheduled at short notice. There was a lot of excitement in the class, and this had an impact on the children's engagement with the focus group. The focus groups took place in an empty classroom next-door to the children's classroom. The door between the rooms was left open at all times and the classroom teacher was present. The children were broken up into seven groups at random. The group size ranged from two to three children. One child asked to not participate after a few minutes in her group, and she returned to the class. There were three children absent on the day of the focus groups due to illness, this was significant given the small scale of the study. All of the focus group interviews were successfully transcribed. Similar to the activity transcriptions, children were assigned a code for anonymity. The teacher interview took place four weeks after the intervention. Due to COVID restrictions, the interview took place over the phone.

Over the six-week period of the research activity, the classroom was a busy environment. Day to day, many other whole school activities took place; children were taken for reading groups with the learning support teacher, standardised tests took place, whole school activities were scheduled, and children were absent from school. This had an impact on certain group's participation, which is evident from Table 16. The busy environment of the classroom was a positive factor for the implementation of the activity in a real world setting but it had a negative impact when gathering data on each group.

The layout of the questionnaires for the research project is consistent with the Clark (2005b); Gadd and Cable (2000) approach whereby children colour faces to indicate their response. This is similar in other curricular questionnaires (SPHE curriculum) as indicated in Section 4.9.2. While the questionnaires were useful in gaining a general understanding of the children's attitudes towards Irish and the use of the floor-programmable robots, a review of the results and observations during the results of the questionnaires shows that the results did not always match the children's verbal answers. Observations during the questionnaires showed that the children were sometimes influenced by their peers (section 7.6.2). This phenomenon was more evident in the post-intervention questionnaire as the teacher observed the children during the activity and could identify children who were motivated but answered the opposite on the questionnaire. As suggested by Clark (2005a), questionnaires are at risk of becoming *tokenistic* during research with young children and may not always be the most reliable source of data for this small cohort of research participants. These findings support the need to triangulate findings when conducting research.

Interestingly, gathering the children's perspectives through questionnaires and focus groups had a positive impact on the children's outlook whether their response was positive or negative. The findings from pilot cycle two and cycle four indicate the impact the process of undertaking a questionnaire and being asked for their opinion had on the children. The children discussed this during the focus group and how they liked being asked what they thought and that it was not common practice in the classroom from their perspective. This is important as it shows that asking young children for their perspective on classroom activities and their use of resources is important for their active engagement in classroom activities. It is possible that the children may have viewed the gathering of their opinions during the research activity in a more formalised manner with the researcher rather than their classroom teacher who asks for the thoughts and opinions on various topics daily.

While the validity and importance of gathering the child's voice through questionnaires is clear it is often difficult with children under the age of 7 (Bell, 2007). When conducting the questionnaires with the children the terminology of the questions was confusing for a number of participants and further explanation was required. Similar to Bell (2007)'s research with the National Centre for Social Research the children questioned the word technology and what did it mean. During Bell's (2007) study the word personal in personal computer was taken literally to mean for their own use rather than the family computer as was intended by the question. Similarly, during this study, the children were not sure what technology meant and identified some items such as a games console and the teacher's desktop computer as technology however iPads, the interactive whiteboard and Bee-Bot were not viewed as technology.

Designing a questionnaire for young children is a tricky process as their cognitive ability and prior knowledge at this young age must be considered. As Bell (2007), Schwarz & Sudman (1996) outline there are four mental processes which a research participant must go through; comprehension of the question, memory retrieval of information required to answer effectively; making a judgement; and finally communicating a response. The results indicate a majority of children answered the questionnaire using an *optimising strategy* whereby they moved through this process effectively (Krosnick, 1991; Vaillancourt, 1973), 1973). However, for others they were observed using the *satisficing strategy* whereby they resorted to answering the question in another way, such as selecting the first answer, and some were observed aligning their answers with the person sitting beside them. This became more apparent in the post intervention questionnaire whereby children were observed enjoying the activity and confirmed this verbally, but they answered negatively in the questionnaire. The limitation of questionnaires with young children is that it is often difficult to ascertain whether children are answering truthfully. Their answers may mirror their classmates, and the questionnaire may not reflect their true feelings on the topic (Dörnyei, 2010)). Observations during the questionnaire also saw the children found it difficult to turn the pages and navigate the questionnaires. Considering the DBR process, the questionnaires were trialled during the pilot cycles however, a critical review of the questionnaire must take place prior to its application in the future so that the children can use the *optimising strategy* to answer a questionnaire (section 4.9.2).

The data gathered from the focus groups varied from group to group. The children were familiar with the researcher and a focus group was conducted while some of the children were happy to discuss the activity and learning Irish (Section 7.5.2) others said very little and did not contribute to the focus group. According to Clark (2005a) young children may be shy and may not have the confidence to participate in a focus group. During this research, the children were organised into focus groups of three. This gave the researcher the opportunity to speak to the children and gain more insight into the research intervention. However, it had the opposite effect on some of the groups. During one focus group one child opted to leave the focus group once they understood the purpose of the focus group. The researcher was required to prompt the children a number of times to recall specific details about the Bee-Bot activity. As the children became monosyllabic (Clark, 2005a) with their answers, short video clips from the research activity were introduced as a strategy to prompt a response from the children. The use of video stimulated recall was effective. It created an additional level of familiarity for the children during the discussion with the researcher. While the use of video clips was effective, a short conversation after the activity may have had a similar if not better response and provided more information rather than the use of separate focus groups at the end of the six weeks. The results of the focus group indicate that the children’s classroom teacher may have been best placed to gather information from the groups as the children were more familiar with her and could have open conversations with her. Upon reflection it would also have given the children the opportunity to discuss tasks they had completed on that day and the group may have felt more confident in contributing.

6.5 Conclusion

This chapter comprehensively describes the procedures employed in the final cycle of the Design-Based Research (DBR) study. It begins by addressing essential pedagogical considerations, followed by a detailed outline of the participants involved in the study (Section 6.1), the duration of the intervention (Section 6.2), and specific aspects of data collection and analysis (Section 6.4). Notably, Section 6.4 builds upon the methodologies previously outlined in Section 4.8. As previously indicated, the fourth cycle was specifically utilised to investigate the research questions outlined in Section 4.2. In the upcoming chapter will present the results derived from the fourth cycle of the DBR study, which will shed light on the outcomes and findings of the research. The academic style employed in this chapter ensures a rigorous and systematic approach to presenting the research procedures, facilitating a clear understanding of the study's design and execution.

7 Results

7.1 Introduction

This chapter will present the findings from cycle four. The research instruments that informed the results of this study can be found in section 4.7. The results of this study are presented according to the three areas of investigation. Section 7.2 presents a sociocultural analysis. Section 7.3 presents the language analysis of the transcripts. This section will present results from each of the groups individually and the results from the teacher's language usage during the research activity. Section 7.4 presents the overall findings on CT skill analysis as well as further analysis of the orange group who undertook the maximum number of days allocated for the research activity. Section 7.5 presents the children's perspectives of the research activity. This section provides results from the questionnaires the children undertook and the focus groups that took place after the research activity. The final section 7.6 of this chapter provides findings on the teacher's perspective of the activity.

7.2 Sociocultural theory

This section will present the findings from the SCT analysis carried out on the video recordings of this six-week research activity. The analysis of the SCT constructs in the data is contextualised by the interactions between the children, the children and the teacher and the children and the activity and resources used. In particular, their engagement with the Irish language and with Bee-Bot. To describe SCT and all its constructs over a six-week period is to tell a story of the children's development in the relevant areas and how their development was mediated. The method for coding the transcripts and the video recordings is outlined in section 4.9. The researcher used a priori codes as set out in section 4.9.3. Figure 9 gives an outline of the order in which observations of these constructs will be presented and the subsections under each of these constructs.

7.2.1 Mediation

Mediation has a number of sub constructs that the researcher coded in the transcripts. The number of times each of these were identified in the transcripts is outlined in Appendix S. Mediation was observed in three ways during the research activity through the classroom teacher, through the use of the floor robot and through the use of the floor mat the teacher supplied. Every time the child was tasked with moving Bee-Bot it was logged as the construct of mediation as the child used it as an "object to think with."

To give the children physical support during the activity, the researcher and the teacher created charts that the children could use throughout the activity to track Bee-Bot's movements and also draw attention to pictures associated with their new language. This support was introduced to help the children track the story associated with their target language. There were two versions of this chart, one with arrows and one with arrows and pictures. Along with the chart, there were small versions of the pictures on the mat the children could place on the chart.

Figure 13 Orange group using supports

Over the six-week period, the teacher introduced both chart types to the children. Children can be observed during the activity using charts and pictures. After a short time, some children lose interest in maintaining the chart and focus entirely on the main activity mat. Some of the children who are quieter in the group kept going with the chart and organising the pictures. While the teacher was dealing with another group of children one day, the green group were observed using the pictures cards to tell a story and organised the pictures according to the sequence of events. They waited for the teacher to return before engaging with Bee-Bot again but carried on happily using their target language with the picture cards.

7.2.2 Regulation

Throughout the activity, the children demonstrated various regulation strategies to accomplish their tasks. These strategies involved physical interaction with objects, feedback from their teacher and peers, and skill acquisition to foster self-regulation. The process of regulation was carefully observed and documented, capturing the children's progress from dependency to independence in handling the new activity. The successful utilisation of the target language and the completion of tasks with Bee-Bot served as evidence of their development in regulation.

Among the objects used during the activity, the floor mat held particular significance. It provided a visual guide for the children to determine Bee-Bot's path and narrate the fairy-tale or story associated with Bee-Bot's movements. The familiarity of the pictures and story facilitated their early engagement until the final day when they were challenged to create their own narrative. This change in object regulation led the children to rely more on other regulatory methods. The teacher played a more supportive role on those days, assisting the children in recalling their initial story creation and guiding them through the tasks. Consequently, this shift impacted their language usage and the time taken to complete tasks with Bee-Bot.

Another crucial object was Bee-Bot itself. The programmable floor robot allowed the children to validate whether their coded solutions were correct. It served as a live-action response to their problem-solving efforts. Throughout the six-week period, both the floor mat and Bee-Bot consistently supported the children, including those who acted as More Knowledgeable Others (MKOs) to assist their peers. These MKOs encouraged others by pointing at mat pictures or Bee-Bot's buttons. Additionally, scaffolding was evident when the teacher or another child explicitly offered guidance to a struggling peer during the activity, as coded in the data.

As the children progressed in their development over the six-week activity, self-regulation became more evident. They became proficient in using mediational resources such as Bee-Bot and the mat, reducing their reliance on external support and encouragement. Some children even reached a level of self-regulation where they internalised the effective method of programming Bee-Bot and no longer needed to verbalise the route. This advancement was evident in their increased task completion proficiency. It was also apparent in their language use, as they created stories using complete sentences in the target language. Some even incorporated bilingual sentences, including the Irish language, even though it was not part of the target language list. They recalled and applied this language appropriately, complementing the group's story.

The study's results reveal significant insights into the phenomenon of private speech among children during different tasks. As the children progressed to the self-regulated stage, they demonstrated a shift from relying on external objects or guidance to utilising their internal resources for task completion and learning internalisation. Notably, private speech emerged as a prominent strategy employed by some children during the Bee-

Bot task. This self-directed externalisation of language appeared to help them coordinate their efforts effectively.

During the Bee-Bot task, instances of private speech were observed, wherein children verbalised their thoughts, often responding to their own questions and strategising accordingly. Remarkably, their peers were observed listening attentively and interpreting the speaking child's utterances. It became evident that private speech fostered not only individual problem-solving but also interactive discussions within the group. Some children even offered feedback on the strategies shared through private speech, engaging in supportive interactions by either validating or encouraging alternative approaches.

Additionally, the researcher also observed occurrences of private speech while children interacted with picture cards. In this context, some children engaged in collaborative storytelling, utilising the picture cards as aids. Simultaneously, others leveraged the cards to practice the target language through expressive speech.

These findings shed light on the valuable role of private speech as a means of self-regulation, attention-focusing, problem-solving, and memory support among children. The emergence of private speech during the different tasks underscores its importance in language development and its potential to facilitate effective communication and learning strategies in educational settings. The study highlights how self-directed verbalisation can enhance both individual and group learning experiences, fostering a dynamic and interactive learning environment among young learners.

7.2.3 Internalisation

Internalisation, is a complex construct within SCT and poses a challenge when translating it into data analysis. It involves observing children effortlessly applying their acquired knowledge. This phenomenon unfolds gradually within the learners' minds over a period of time, making it less concrete compared to mediation, which employs external tools to aid learning.

However, internalisation was observed during the data analysis. During the research intervention, internalisation was observed during the children’s ease of language output and the confidence with which they completed their task with Bee-Bot. This also included times when the child may not have completed the task the first time and needed to make additional attempts. Some children are observed during the recordings accessing a mediating strategy to help debug the issue and carry on. This can be observed through their hand movements. Through their experience of the activity, it appeared they internalised various strategies demonstrated by their teacher and others in the group and seemed confident in carrying on without any assistance. In terms of language learning, the children's use of target language increased during the research intervention which would indicated internalisation of learning.

An example of internalisation appears when a group of children are having a discussion during the activity about the pictures on the mat. While one child says the wrong word associated with the picture, but it's a rhyming word (súil – eye, úll – apple), the other children question the child and extend their own learning by discussing the word much in the same way as the teacher had demonstrated at the start of the research activity. It is the ease at which this conversation takes place amongst the children without any difficulty in recalling the relevant target language that indicates how they have moved from the interpsychological plane to the intrapsychological plane, and the knowledge is embedded.

7.2.4 The ZPD and the MKO

As previously described in chapter 2, the Vygotskian ZPD concept affirms that development arises through collaborative mediation, whereby the teacher or a peer interact and provide guided support to the learner, which is expected to help the child to better perform a task (Ellis & Shintani, 2014). ZPD indicates what an individual is capable of doing with mediation at one point they will be able to do without mediation at a future point. With the ZPD, a child's development could be predicted in advance of the activity on the basis of their response to mediation. During this activity, however, that was not always the case. The teacher commented that she was surprised by the performance of some children and how they excelled and was equally surprised at other children whom she would have assumed the stronger children and how they were more reluctant to participate, and their response to mediation was not as strong as she would have expected. During the six weeks, the results from the language and CT analysis confirm that there was a developmental shift within all the children. This was reflected in different ways, however, and was not always attributed to their task completion or the number of Irish words uttered. For some of the children, this development within the ZPD was represented by their confidence in carrying out tasks, their ability to mix Irish and English to convey meaning and also the assertiveness to ask for assistance when they realised, they needed it.

During this research activity, the children were assigned a number of CT tasks, and they were challenged to use their second language during the activity. Through the review of the video recordings and transcript, the researcher observed that there was at least one

MKO in each group. Some collaborated with the other children, while others were more instructive. The children who were identified as MKO's from the video recordings performed a number of mediating tasks. During the green group's initial activity session, GC1 acted as the MKO. When the teacher departed the group allowing the children to take on the activity by themselves, this child began moderating the tasks similar to the teacher. This child ensured that everyone had a chance to perform a task with Bee-Bot while also supporting them through the task with scaffolding language.

GC1 appeared to be aware that GC2 would struggle with the task and ensured that he received additional support. This was demonstrated through hand gestures and through the use of directional language in Irish. Sometimes GC1 support became explicit and moved beyond being supportive and was directive. As the children assigned each other, the task GC1 ensured that the task length and complexity was within a sufficient range for GC2 to complete. We can see from the transcription below that GC1 often referred and the buttons on the robot both physically and verbally, using the robot as object-regulatory support for others. The mat on which the activity took place was also mediating support as the children pointing to the various pictures while supporting each other. Linking to section 7.3.2, Lantolf et al. (2015), identify other-regulation in the form of guidance from an expert or more knowledgeable other.

There was another child in the green group who took on the role of MKO during day four and day five. While GC1 participated, he was not vocal in supporting others during those days. GC3 had a different approach to being the MKO which was less directive and offered suggestions and continued support of others through praise. These two children from the green group were both strong in their Irish language use and also in their computational skill development. Where their impact as MKO's is observed is through the performance of the other children. Through their encouragement and scaffolding, we observe a change in behaviour in GC5 and GC6. Both of these children began the research activity quite unsure about what to do and were nervous. By their fourth session, these children did not seek support as much as they had in the previous session and confidence in their actions can be observed in the video recordings. GC6 programmes Bee-Bot without hesitation, whereas previously, her finger wavered over the buttons as she tried to plot a route for Bee-Bot. She was quiet in her approach but consistent throughout. She also used hand gestures to assist others. As this happens, both the MKO and the child co-construct a metaphorical space, the ZPD. While these children are recognised as the MKO of the group and supported their peers the findings indicate that they did not always have a positive impact on the ZPD of their peers. The

Green group is an example of this whereby GC1 acts as the MKO. They are observed supporting others in particular GC2. They act in a similar manner to the classroom teacher describing the course of the activity and differentiating for others. While this discovery highlights the positive role of peers as MKOs, it's apparent from the video footage that this particular child also posed an obstacle to the progress of other children. At this young age children can support others, but they are not the skilled teacher and so while GC1 extending the activity and supported others they became dominant in the group and rather than support they dictated.

7.2.5 Scaffolding

During the research activity, the teacher and the children were observed providing scaffolding to support each other in the Bee-Bot activity. Scaffolding was provided explicitly and focused on helping the children use Bee-Bot effectively and complete their tasks. It was coded based on the amount and frequency of support offered. This was not unexpected, considering that the activity was new to the children, and they visibly needed support to program Bee-Bot effectively. The teacher's scaffolding played a crucial role in contributing to the children's computational skill development, as each attempt at the tasks was accompanied by the teacher's support in debugging any issues with the programming.

Figure 14 Children using directional cards to plot their story

The researcher recorded the occurrences of explicit scaffolding provided by the children to their peers. Notably, the same children who acted as More Knowledgeable Others (MKOs) in their groups were also observed giving explicit scaffolding to others. These confident and self-regulated children naturally offered support to their peers during the activity. Specific examples of explicit scaffolding with Bee-Bot were documented, with children GC1 and GC6 using Bee-Bot to provide a scaffold to others. For instance, GC1 physically moved another child's hand across the buttons, serving as their scaffold, while

GC6 pointed to the buttons to guide another child. GC1 was identified as the MKO in the group, whereas GC6 did not serve as an MKO but still offered scaffolding to others, including two instances on their last day.

Throughout the research activity, the use of physical supports or scaffolds was observed, both in the form of classroom resources and through physical gestures and language. Prior to the six-week research intervention with Bee-Bot, the children engaged in unplugged activities that utilised physical resources to develop their directional language (see Appendix A). To maintain continuity, these resources were adapted and incorporated into the Bee-Bot research project.

Figure 15 Playing card supports

During the Bee-Bot activity, the children used directional cards to support each other. Initially, these resources played a significant role in each group's experience with the activity. However, there were instances when the resources, such as the route mat used to track Bee-Bot's movements, proved to be of minimal use to the children and led to confusion. Most of the children preferred using small playing cards for sorting and creating their own stories, and this activity supported their language usage, including the use of the Irish language (see Appendix B). Despite the physical scaffolds not always fulfilling their intended use during the activity, they served an alternative purpose by inspiring conversations among the children using their target language and extending their language use beyond the research activity's focus.

This section provided an overview of the analysis of Sociocultural Theory (SCT) constructs observed during the research activity. SCT offered a comprehensive framework for understanding the children's development in various aspects during the activity, including language, computational thinking, and teamwork skills. The SCT constructs allowed for breaking down the activity and capturing snapshots of development in a group setting. Some constructs were analysed in detail through the coding of transcripts, while others were observed using a qualitative approach across six weeks. In the following sections, these constructs, such as internalisation, Zone of

Proximal Development (ZPD), and More Knowledgeable Other (MKO), will be further explored in relation to language and computational thinking (Appendix R and S).

7.3 Language

This section will look at the children's language development over the six-week research activity. The purpose of the language analysis was to identify whether the target Irish language taught during the language lessons (Appendix L) was used by the children and became part of the activity. An analysis was also carried out on the increase in usage of this language over six weeks of the research activity. The section will outline the overall language development of the whole class, along with indications of significant results from each group. Following this, the language analysis from one group (the orange group) are presented as a learning journey over each day of the activity. This provides a perspective on the activity outline, daily outcomes, and the supports used during each session by the teacher. The additional three groups are presented in a more refined format. As the children used social, target and the functional Irish language, the language analysis was separated into two sections: social and target language associated with the stories; and directional language associated with Bee-Bot (section 4.9.3). The social and target language were grouped together as during a review of the transcripts, it was evident that both the social language and target language are interwoven during the children's engagement with the activity, and so they were combined for analysis. The output from each child included for data analysis was a mixture of Irish and English which can be reviewed in Appendix P. Any output from the children that was only English was not included for language analysis.

Figure 16 Bee-Bot and the floor mat

7.3.1 Social, target and functional language

The language associated with each story during the activity came from the three topics taught by the teacher in the Irish language lessons over six weeks. The three topics and the target language associated with them are listed in Appendix J. The transcripts were analysed for these words along with social language, and each word was logged per child and summarised per group. The time in which these words were used by the children in a call and response with the teacher are not logged as the children were repeating the words rather than recalling them from memory or internalisation.

The functional language used by the children when directing Bee-Bot was “ar aghaidh“ (forward), “siar“ (backwards), “ar dheis“ (right) and “ar chlé“ (left). The children also heard this language from Bee-Bot when each corresponding button was pressed and as Bee-Bot executed the coded route. This functional language was also logged separately and then combined with the social and target language for an overall view of the Irish language used.

As noted in section 6.4.2, the children had varying amounts of time with the research activity. The purple group had the least amount of time with only three days to attend the activity over six weeks. From Table 17, we can see that the output from each group varied. While the green group and the orange group maintained a similar level of output, so too did the yellow and purple. The yellow group one extra day on top of the purple group, and they had an additional output of 2 Irish words.

Table 16 Total Irish language output from each group

No. of days participation	Five days	Five days	Four days	Three days
Group	Orange	Green	Yellow	Purple
Total Irish language output during research activity	230	237	142	140

The average Irish language use from each group over each of their sessions can be seen in Appendix P. Overall the children’s use of the Irish language over the six weeks saw a consistent use of the language. The children used more of their social and target language over functional language. In some cases, the functional language was used only as a support for others when they struggled to plot a route with Bee-Bot. From Appendix S, we can see that on day three of the activity, the four groups, on average used Irish consistently. The orange group continued to improve on day four, but they had a drop of 3.3 on day 5. The median score is shown in Table 17 Language used across all groups below, which gives a clearer indication of the Irish words used across individuals.

Table 17 Language used across all groups

Language used across all groups					
	Day 1	Day 2	Day 3	Day 4	Day 5
Average	6	7.9	11	11.3	11.4
Standard deviation	7.3	5.8	9.9	7.6	10
Median	3	7	6.5	9	7

The target language used aligned with the language the teacher was teaching and the informal Irish language used throughout the day such as, positive reinforcement and language taught prior to the intervention. Initially the children used this directional language while scaffolding themselves to direct Bee-Bot through private speech or when they were scaffolding others. The findings show that over six weeks less and less functional language was used by the children. An example of this is CH2 from the Orange group (Appendix N) who had a consistently high output of Irish language across the research intervention but even their use of functional language decreased. There are two possible explanations for this. Firstly, Bee-Bot announced the direction each time the associated button was pressed. Over the weeks the children heard this language again and again. It is possible the language was internalised, and the children knew the directions and therefore did not feel the need to say them aloud. Secondly, as indicated by CH2 during the focus group, he was of the opinion that saying it out loud was cheating and that the other members of the group would know the mental plan he had for Bee-Bot. They believed the directions should not be said out loud and this was part of the game.

7.3.2 Orange Group

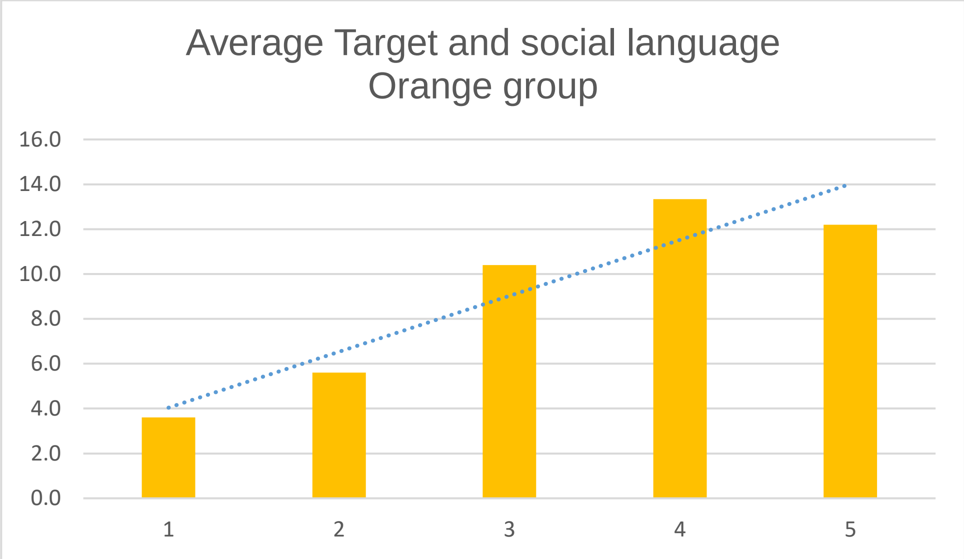


Figure 17 Orange group: average target and social language

The orange group was one of two groups in the class to participate in five sessions of the Bee-Bot activity with their teacher. Over the five sessions, the children covered all the three topics from the language lessons. They also had two sessions where they created their own story. This section look at this groups engagement with the activity day by day.

On day one, the class teacher distributed A4 support pages at the start of the session. The children had practiced using these cards the day before, and the teacher reminded them of this. The teacher also distributed small pictures which reflect the pictures on the main Bee-Bot mat. The mat on day one was focused on *Teidí sa Pháirc*. The children were distracted by the cards and began sorting them. The teacher called for their attention and revised the pictures on the mat with them. The children were engaged in questioning from the teacher, which was in Irish. There was a mixture of the children answering questions and call and response with the teacher.

**TEA:*	*Cad é seo?*
**ALL:*	*Lámh.*
**CH4:*	*Ceann.*
**TEA:*	*Ceann ach tá Teidí ag?*
**CH2:*	*wah wah wah.*
%act:	*rubbing eyes to pretend he's crying*
**TEA:*	*Tá Teidí ag caoineadh.*
**TEA:*	*Cad é seo?*
**TEA:*	*Teidí bocht.*
**ALL:*	*Teidí bocht.*
**TEA:*	*OC3 agus OC1 you have got these as well?*
**TEA:*	*Cad é seo?*
**CH3:*	*Leaba.*
**TEA:*	*Leaba ar fheabhas OC3.*
**CH5:*	*0[% clapping].*

As the teacher placed Bee-bot on the mat to introduce the activity to the children, their interest was piqued. We observe OC3 watching OC4 intently, giving directions to Bee-Bot. All children watched Bee-Bot moving across the mat. The teacher showed them how to use the support page, putting small cards on pages one by one. One child has the cards laid out on the floor, but already we can see that the activity with the cards is too demanding on their attention.

OC5 can be seen with their back turned to the Bee-Bot activity and playing with the cards. There is a lack of engagement in the Bee-Bot activity from this child, but they were happily playing with the cards. Some of the children are reminded in this session about the need to press x before they begin coding. The teacher encourages the children to say where Bee-Bot is when he lands on a specific picture. As OC3 sends Bee-Bot in the wrong direction, his solution is to pick up Bee-bot and replace him where he was. The teacher reminds him that he must code Bee-bot to get him back on track. As the session progresses, it becomes apparent that OC3 is very excited about the activity and can sometimes take over another child's turn but can also be very helpful at instructing others. OC3 can be seen strategising by counting out a route to support his coding; he comments at the end that this was hard but says it in a positive way.

**CH1:*	*That is broken.*
**TEA:*	*Níl sé briste.*
%act:	*Picks up Bee-Bot.*
**CH1:*	*It's broken if it goes the wrong way.*
**CH3:*	*That's mad.*
**TEA:*	*OC3 déan é uair amháin eile.*
%act:	*Places Bee-Bot back on the mat*
**CH3:*	*Yeah.*
**TEA:*	*brú x ar dtús.*
%sct:	*SCA: TEA*
**CH3:*	*0[% presses x].*
**TEA:*	*So, you are going to go ar aghaidh ar aghaidh.*
**CH3:*	*Ar aghaidh, Ar aghaidh, Ar aghaidh, Ar aghaidh, Ar aghaidh, Ar aghaidh and ar dheis.*
%comp:	*ABS: LANG*
%comp:	*GEN: LANG*
**CH3:*	*0[% OC3 plots out a route for Bee-Bot].*
**CH3:*	*0[% points to squares and calling out directions to match].*
%comp:	*ALG: LANG*
**CH1:*	*Teacher, what would happen if you just pressed go.*
**TEA:*	*He would just do all the things you asked him to do the last time.*
**CH3:*	*0[% presses forward four times].*
%comp:	*ALG: BOT*
**CH3:*	*0[% stops to count out steps, goes back presses forward, right and go].*
%comp:	*ALG: BOT*
**TEA:*	*Maith fear OC3.*
**BEE:*	*Bee-Bot stops one forward step short.*
**TEA:*	*Beagnach ann OC3 brú x uair amháin eile.*
**CH3:*	*0[% presses x, forward and go].*
%comp:	*ABS: BOT*
**CH3:*	*Go!*

On day two, the focus on the mat is the three little pigs. The teacher begins the session again by asking about the pictures. The teacher reminds the children that some of them would have missed some days, so not to worry if the words are unfamiliar to them. The teacher revises the pictures by asking the children to call them out. OC3 and OC4 appear very interested and responsive, and OC5, who did not engage in session one, is happy to answer questions in Irish. The teacher points out that they're going to tell the story of the three little pigs and direct Bee-bot around the mat. All children appear happy and relaxed. OC1 uses one hand to count out the steps Bee-Bot would take as he inputs the code with his other hand. OC4 used their hand as well to keep track of what she is coding. While OC2 is coding, we can hear the teacher answering questions from other groups of children. OC2 also uses this strategy of counting with one hand while coding with the other hand. OC1 doesn't seem as interested in the activity when he's not coding. He asks the teacher when the session will be finished. OC3 plans a route saying how he'll get there in Irish which can be seen in Sample Day 2. OC2 is given a longer task to complete, and as he begins to break down the route, he sets a target "*I'll get it to here and see"*. The teacher splits the task with CH3. We begin to observe the teacher setting tasks of varying difficulty for the children, and she assigns easier tasks to those who find it challenging.

**TEA:*	*Cur Bee-Bot go dtí an mac tíre.*
**TEA:*	*CH1, you need to suí suas if you are going to be having a turn in a few moments.*
**CH3:*	*0[% presses x].*
%comp:	*ALG: BOT*
**CH3:*	*I think I'll go siar siar siar.*
%comp:	*DEC: BOT*
%act:	*Pointing out the steps as he says it.*
**TEA:*	*So, you have to go siar siar.*
%act:	*pointing out steps.*
**CH3:*	*And then I have to turn.*
%comp:	*DEC: LANG*
**CH3:*	*0[% presses backwards five times, left, go].*
%comp:	*ALG: BOT*

On day three, the children had pages and small cards again. The story on the mat is about the three little pigs again, but some of the cards have been rearranged on the mat. The teacher began by asking questions about the pictures. She asked questions such as *"Can you name anything on the mat? Cá bhfuil an mac tíre? Let's name everything together."* As the group begins to go through the story, CH2 starts by saying "*fadó fadó"*. He is the only child across all four groups over six weeks who says this. It is the opening line of the story, which translate into English *once upon a time*.

**TEA:*	*So, we are going to tell the story of na trí muicín.*
**TEA:*	*Ok, can you remember the story?*
**TEA:*	*How does it start?*

**CH4:*	*0[% One child points to teach tuí].*
%comp:	*ABS: LANG*
**TEA:*	*Yeah, so bhí trí muicín ann, so everybody get the pictiúr trí muicín.*
**CH2:*	*Fadó.*
**TEA:*	*Oh, wow, saying it again.*
**CH2:*	*Fadó fadó.*
**CH2:*	*Bhí trí muicín ann.*
**TEA:*	*Ar fheabhas Tommaso cur Bee-Bot go dtí na trí muicín.*

As the children began to code, OC1 tracked his coding with his hand. Since the last session, the sound on the Bee-Bot for when he turns right now is now a muffled sound. This really bothers OC5 as when she takes her turn, the sound of the direction being called out by Bee-Bot was a confirmation of the correct turn taken. The teacher has to step away during the session to deal with another teacher visiting the classroom. OC5 stops coding because the unfamiliar noise bothers her. All the other children are happily playing with the cards. The teacher returned and helped OC5. She attempts the task, and Bee-Bot goes off the mat. During this time, the teacher has to leave the group again; when she returns, she forgets that OC5 was attempting a task. The teacher replaced Bee-Bot on the mat, and OC4 carries on with the task. OC5 completes the last task of the session but relies on support from the others in the group. They can be heard instructing her in Irish. She completes the task in two attempts.
On day four of the activity, the teacher set up the activity so that the children were making up their own stories. As she distributed the pictures cards, she described the activity to the children and how they could work together to create a story by using all the picture cards and words they knew in Irish.

Figure 18 Story cards

OC3 talked about seacláid and cáca. As the children select some of the picture cards, the teacher goes through all the words asking various questions. The children try to use their Irish words, and anytime they say a word in English they've learned before in Irish, the teacher reminds them. The children create a story together in Irish. The teacher repeats the story to the children when all the cards are placed inside the pockets on the mat. The teacher is playful with her language and leaves the last word out of the sentence so that the children are prompted to call out the correct word. Some interesting observation arose during the activity on day four whereby OC2 is observed having difficulty in tracking with a left turn and forward, OC3 appears to be able to visualise his mistakes and how to correct them, and OC5 needs the support of the teacher during her turn.

**TEA: Can you think of what's going to happen in the scéal?*
**CH3: I think the carr is going to go to the milseáin shop and then.*
**TEA: The carr is going to go to the siopa, is it?*
**CH3: Yeah, and then buy some after.*
**TEA: And who is going to be ag tiomáint an charr?*
**TEA: An unicorn nó na trí muicín?*
**TEA: Ag tiomáint?*
**TEA: Who's going to be ag tiomáint?*
**CH3: Trí muicín.*
**TEA: Na trí muicín ag tiomáint an charr agus téann siad go dtí an siopa agus cad a cheannaíonn siad sa siopa?*
**TEA: Ceannaíonn siad?*
**TEA: Uachtar reoite.*
**TEA: Ceannaíonn siad aon rud eile?*
**CH3: Aon rud eile.*
**TEA: An cheannaíonn siad cáca agus oráiste?*
**CH3: Níl.*
**TEA: Níl ok.*
**TEA: Agus cad eile a tharlaíonn sa scéal where does the bindealán come into the scéal?*
**TEA: Why do we have a bindealán OC3?*
**CH2: Because someone got hurt when they were driving.*
**CH3: Because they break their ankle.*
**TEA: Oh, bhí timpiste ann, timpiste pew.*
**CH3: They break their ankle from driving.*
**TEA: Briseann siad a chos.*
**CH2: Yeah, because all the trí muicín fell out.*
**TEA: Thit siad ar an talamh.*
**CH2: Yes.*
**TEA: Agus ghortaigh siad a chos.*

On day five of the activity, which is the last day of the research activity for this group, the children extend the activity again by asking the children to make up their own stories. This time the children select two pictures independently from the pile of picture cards (Image X). OC4 and OC3 are distracted with all the cards and begin playing with them. OC2, prompted by one of the pictures, begins reciting a poem about *Teidí* which he learned during week one of the research activity. When the teacher returns to the group, she places each card on the floor mat. OC4 is the first child to begin telling the story. While the children are using the picture cards as scaffolds, they are displaying creativity with their new language as they construct a story together. The teacher offers support by contributing link sentences to the story. The children were observed struggling on this day. They had to keep track of the story and carry on completing their task with Bee-Bot. From observation, the children's language skills had developed during day five; however, there seemed to be a cognitive overload on this day when they did not have a fairy-tale or story from their language lesson to follow. The issues arose for some children when they were coding Bee-Bot, and they depended on the teacher a lot more. Some examples of difficulties that arose for the children are as follows; CH5 gets frustrated when Bee-Bot goes the wrong way; CH1 asked to complete a short task but forgets to press x, so Bee-Bot goes far away from his destination; CH2 gets left and right mixed up; CH4 mixes up forward and backwards.

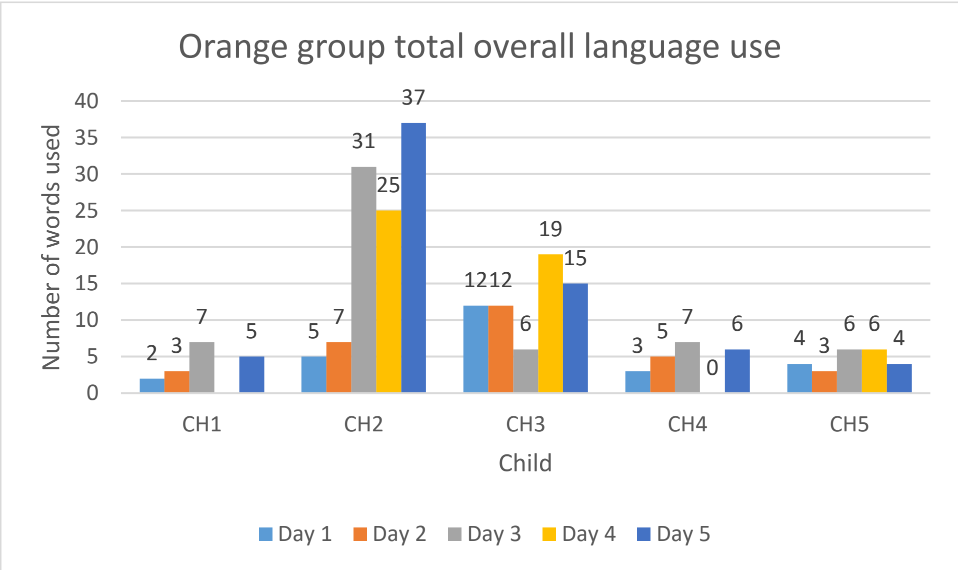


Figure 19 Total overall language use orange group

A sample of language usage from the orange group (appendix M), OC2, and OC3 stand out with the most Irish words used over the five days. As previously mentioned, any words used during call and response were not logged as the child was repeating the word after the teacher. OC2 had an increase in Irish word usage across the five days and on day five had the highest output from the whole group of 37 Irish words. As mentioned, OC2 often used rhymes and songs during the activity, which were all logged during the language analysis. He also played games with the picture cards by sorting them and making up stories with OC4 while waiting for the teacher to return to the activity.

7.3.3 Green Group

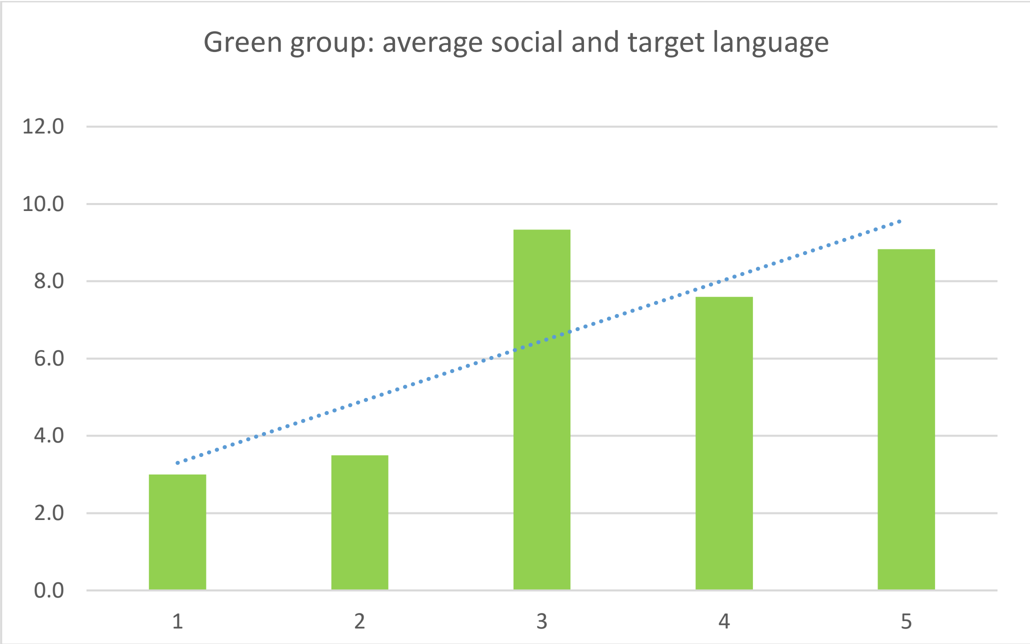


Figure 20 Green group: average social and target language

The green group had six members, and they completed five days of the research activity. The children covered the three target language topics between day one and day four. The total output of the Irish language across the five days was 237 words. On day five of the activity, the children made up their own stories as a group. They maintain a high average output of social and target language on day five. The children used more social and target language (183 words) than directional language (54 words) over the five days. The average output from the children of social and target language increased across the five days, with the most significant increase in the average from day two to day three, as can be seen in figure 9. The children had become more familiar with the target language of the story of the three little pigs and can be observed saying the words more.

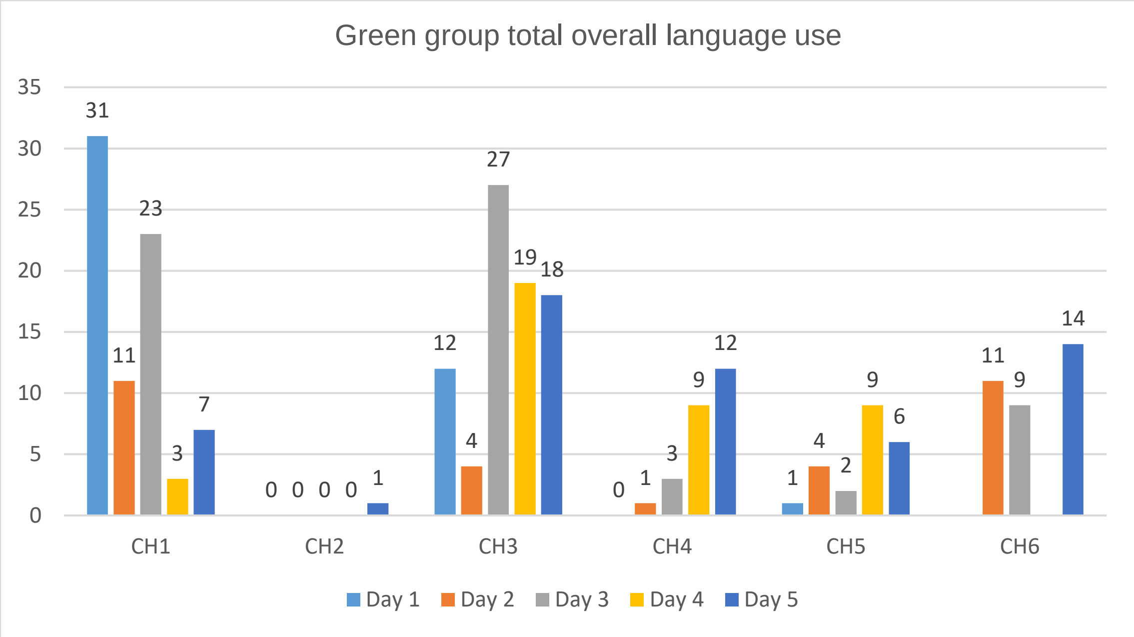


Figure 17 Green group individual overall Irish language usage

As can be seen in Figure 17, CH1 and CH3 made the most significant contribution to the Irish language used across the five days. CH4 was absent on day one, and CH6 was absent on day one and day 3 of the activity. CH2 was absent for day 3 of the activity; however, they remained quiet throughout the other days except for the final day. The teacher confirmed that this was expected for this child. This natural quiet disposition was clearly an established behaviour with his peers as CH1 and CH3 can be seen scaffolding and supporting CH2 throughout the activity. While coding Bee-bot CH2 became more confident across the six weeks and required less scaffolding from others, their language output only began on day 5 when prompted significantly by the teacher. CH1 on day 1 has the most Irish language output across all of the days. A majority of CH1's language on day 1 was directional language as he scaffolded others in their use of Bee-Bot.

Table 23 Green group CH1 Day 1 language use

Day 1	Social/target language used	Directional language used	Total Social and target Language units	Total functional	Total
CH1:	dochtúir, carr, a haon a dó, a trí, a ceathair, sea, carr	Siar, So that's one-two press siar siar siar,téigh, ar aghaidh ar aghaidh again no again and then téigh, ar chlé, ar aghaidh ar aghaidh ar aghaidh, So maybe X maybe he could go to no wait maybe he could go siar cas this way to the súil and then here and then there, And then press ar aghaidh again, And then press ar aghaidh, ok so I'll go siar siar then cas ar chlé and then ar aghaidh	8	23	31

		and ar aghaidh, So, you wanna go ar aghaidh ar chlé.			

There is a drop in CH1's language output on day four and day five of the activity. While CH1 participated and coded Bee-bot effectively, which will be discussed in Section 7.5, on these days, their language output was much less, with three words in total on day 4 and 7 words on day 5. CH3 had an increase in language output on day 3 of the activity and maintenance of outputs across days 4 and 5. Their language output was predominantly social and target language with some directional language. CH3 displayed supportive behaviour towards others during the activity, assisting them with directing Bee-bot and the input of directions.

7.3.4 Yellow Group

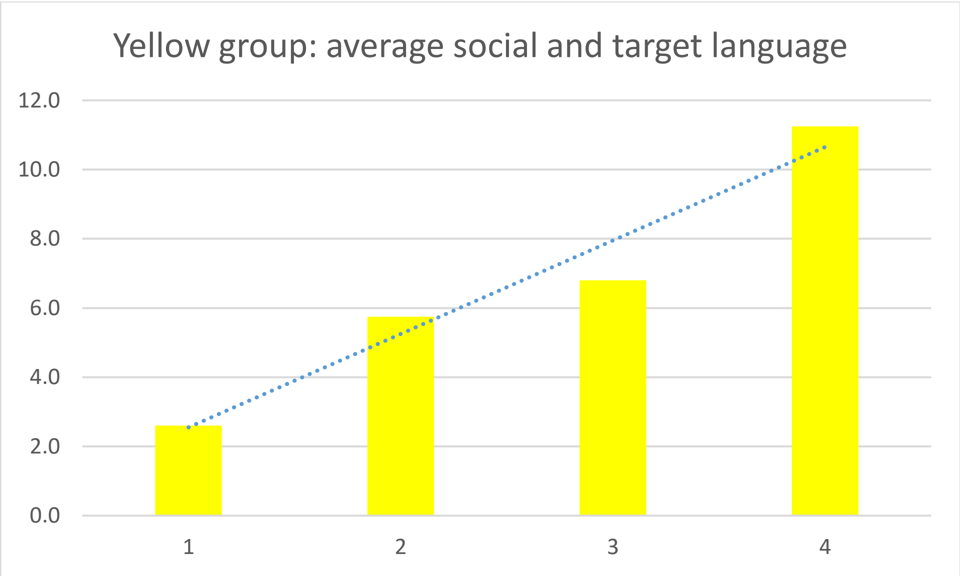


Figure 21 Yellow group: average social and target language

The yellow group participated in the research activity over five does; however, only four were used for data analysis. This group had a consistent average increase in social and target language use over four days. While the children covered all three target language topics, they did not have the opportunity to make up their own stories. While consistent, the yellow group's total language output of 142 words is similar to that of the purple group, which was 140 words over three days. While the children were observed engaging in the activity, there was a considerable difference in the output from individuals in the group.

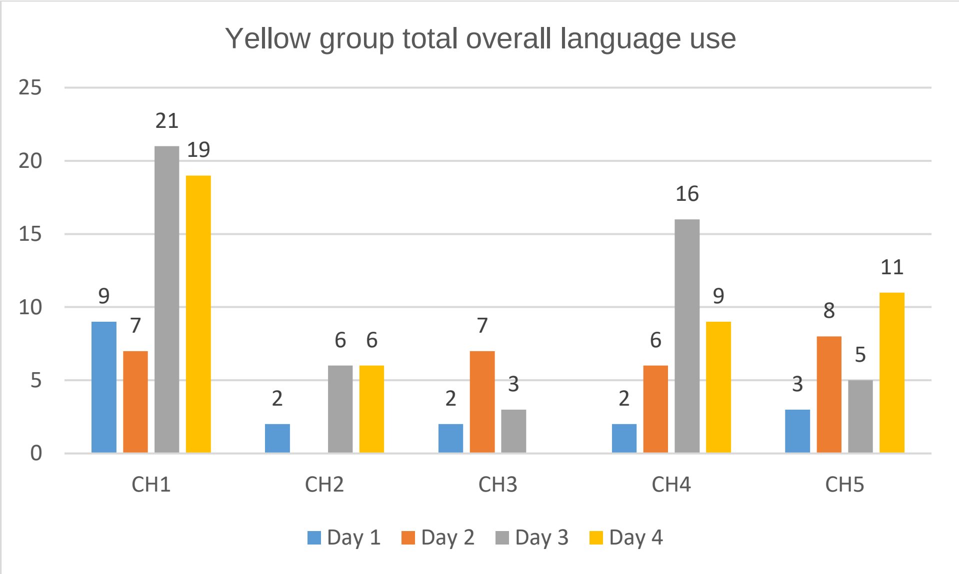


Figure 22 Yellow group total overall language use

Over the course of four days, CH1, CH4, and CH5 consistently participated in the activity. On day 3, these children had to briefly leave and rejoin the group due to attending reading assessments scheduled at the same time as the activity.

Among the children, CH1 consistently produced the most Irish language throughout the four days, incorporating a mix of social and target language, as well as some directional language. On day 3, CH4 showed an increase in Irish language output. Notably, CH4 frequently used directional language, and their language usage was evenly split between social, target, and directional language. While CH5 demonstrated a positive level of language output, the teacher had to provide guidance by asking questions and encouraging them to participate actively and identify words.

On the other hand, CH2 and CH3 were active and engaged participants in the group, visibly enjoying the activity. However, their Irish language usage remained limited, with both of them using seven words or less.

7.3.5 Purple Group

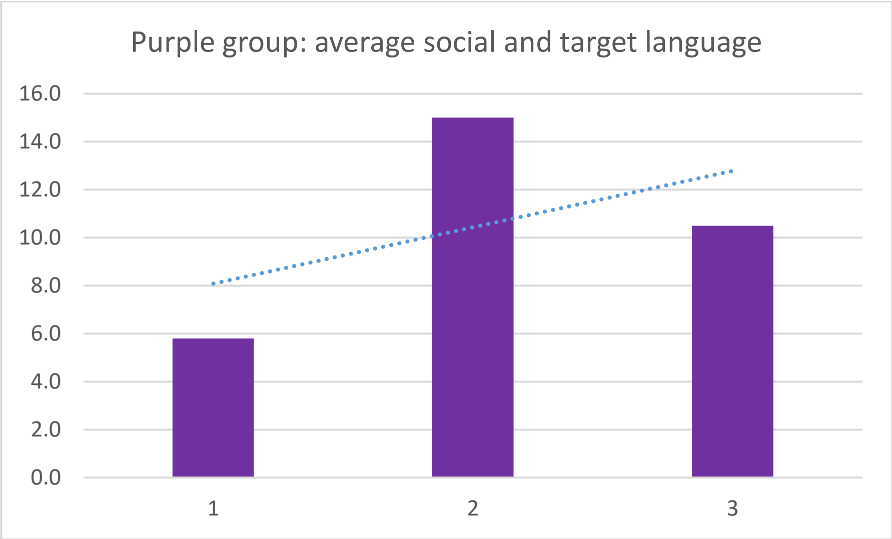


Figure 23 Purple group: average social and target language (Day 1-3)

The purple group took part in the research activity over three days. As previously mentioned, they missed two days of the activity for various reasons. Two members of this group participated in the activity with another group for one day each, but their results are included here as they were originally assigned to the purple group. As reflected in figure 9, the purple group's use of the Irish language increased from day one to day three. There was a significant increase on day two and a small decrease on day three. On day one of the activity, the teacher established the activity and the children's output was in English for the most part, with a total output of 29 Irish words, and two additional Irish words were directional language. On day two of the activity, the focus of the Bee-bot mat was the story of the three little pigs. There was a significant increase as the overall output of social and target Irish words was 60, with one additional Irish word used in directional language. On day three, the output decreased to 42 social and target words and six directional words. The children, on day three, were asked to make up their own stories. As is reflected across other groups, the final day when the children were asked to create their own story and keep track of it as they coded Bee-Bot, presented a significant challenge for the children.

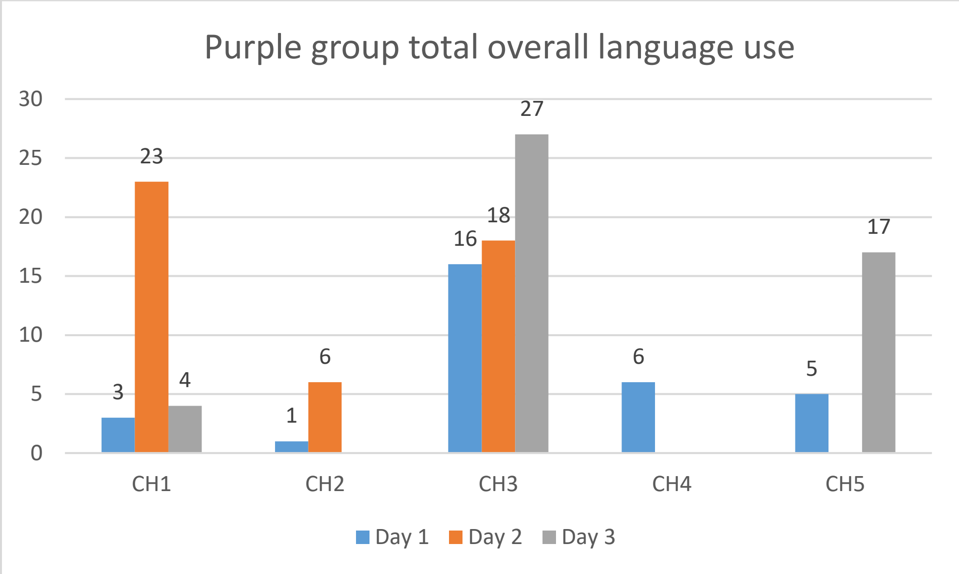


Figure 24 Purple group individual Irish language usage (Day 1-3)

There are two children from the purple whose participation and use of Irish made a significant impact on the results, as is reflected in figure 10. PC1 and PC3 were the two children in the group who had the most opportunity to participate in the activity; they were present for all three days. PC2 and PC5 participated over two days, and PC4 participated on day one. Therefore the results for the purple are significantly different to the other groups. However, PC3 had a consistent increase in their language use, 16 words day 1, 18 words on day 2 and 27 words on day 3. Their use of language is focused on pictures in the Bee-bot mat, but the language used is also reflective of scaffolding others. PC3, during the activity, was recognised as a member of the group who supported and scaffolded others. PC3 can be seen helping others as they struggle with the activity. This is reflected in the use of *maith thú* when praising others achievements and the use of directional language on day three when helping others. The teacher encouraged the children to say *maith thú* to each other if they completed a task, and PC3 is the only child who adopted this behaviour. She repeats it six times during day three. PC1 is another child in the purple group who participated across three days and had a high Irish language output on day two. While PC1 output on days 1 and 3 are low from the video recordings of these days, PC1 was always engaged in the activity. She helped and encouraged others during their tasks, and when the group was asked if they wished to use their free time to carry on with the activity, she consistently opted to stay with the Bee-bot activity after the session had finished.

7.3.6 Teacher's language use

The teacher's language use and input during this activity is arguable one of the most important elements for the success of this activity. Taking on the role, the teacher participated in the design of the study, ensuring that it was adapted to the interests of the children and that is aligned with the curriculum and whole school plan. While this activity did not set out to be a CLIL lesson, the teacher's language usage was nearly 50% in Irish each time she undertook the activity with the children. This is one of the requirements of a CLIL lesson. The teacher maintained this level of Irish input, adapting the vocabulary she used depending on the children in the group and their level of comprehension.

The teacher was the initial and constant mediator and more knowledgeable others during the activity. She can be observed setting out the activity through call and response, which worked effectively with the children. Her language input is consistent, ensuring that the children are familiar with the language associated with the activity before she gives the group more independence to carry on by themselves. Her method of guiding the children is to demonstrate the language, question the children on where certain pictures are and invite the children to contribute. Through storytelling, the children are given this opportunity. The pictures on the floor supported them in their output.

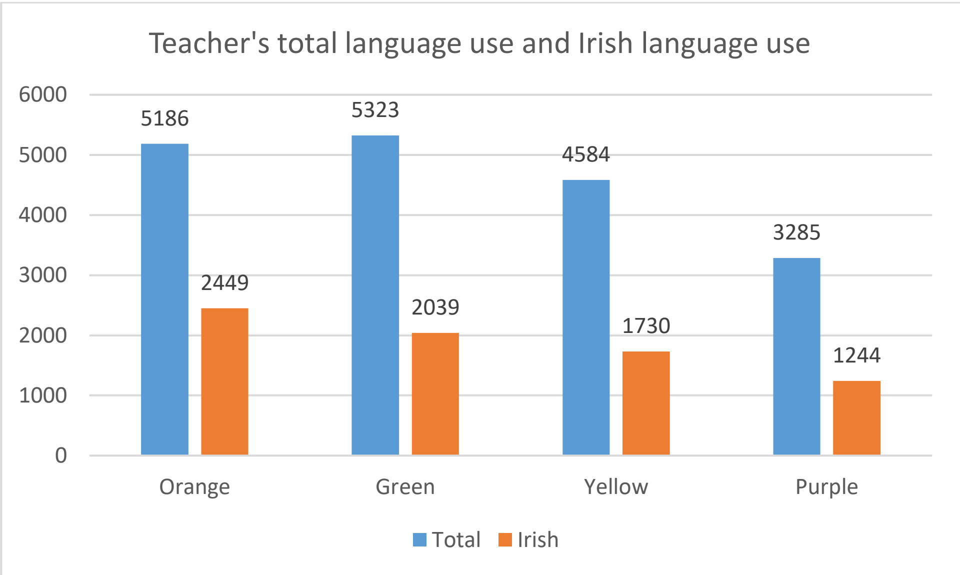
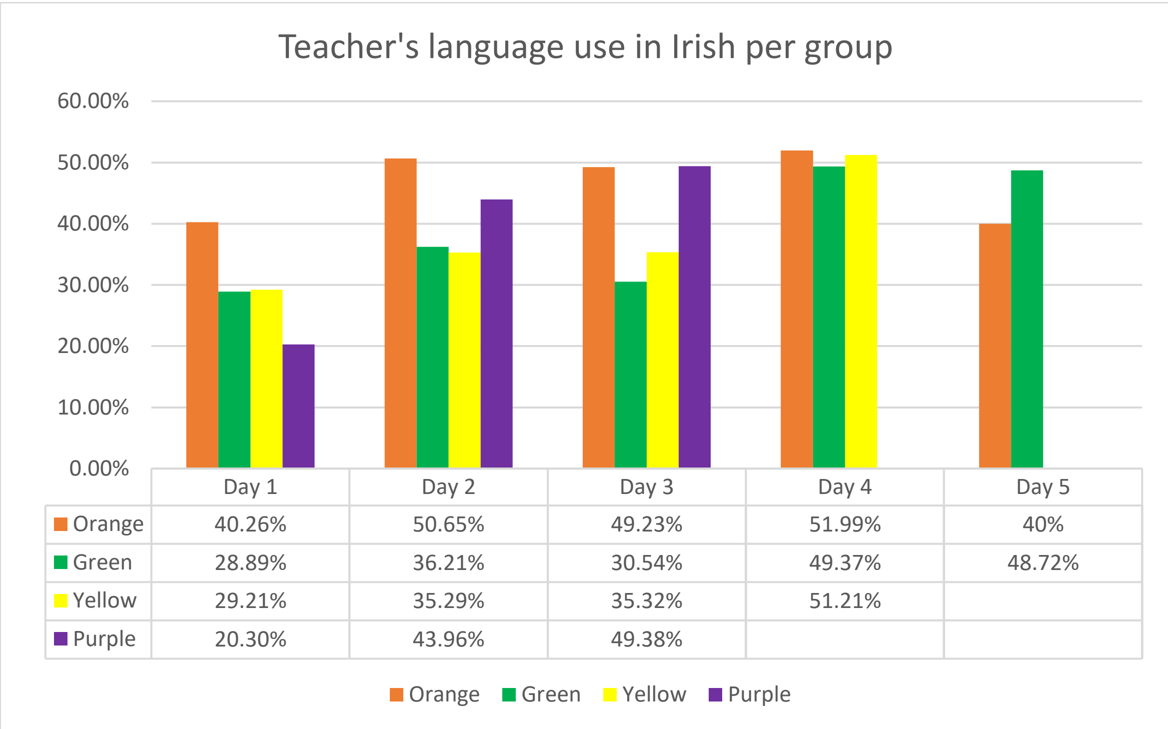


Figure 25 Teacher's language: overall language output and Irish language output

During the six-week research project, the teacher taught an Irish language lesson daily to the whole class and guided one group per day through the Bee-Bot activity. The language used by the teacher throughout the sessions is a mixture between Irish and English. Table 14 shows the overall language used by the teacher for each group in blue, and the portion of that which was Irish is shown in blue. In total, the teacher spoke in Irish 41% of the time over the entire research activity. The overall Irish language use by the teacher ranged from 1244 words in the purple group to 2449 words in the orange group. While it was intended that the each session would be delivered completely through Irish by the classroom teacher the children received input in Irish less than half the time. There was a reduction in language output from the teacher with the yellow and purple groups, which can be accounted for by the reduced number of activity days those groups had. The orange and green groups both had five sessions each, and the teacher language usage is similar across both.

The teacher's language use ranges across the sessions with each group, where she takes the children through each picture on the mat and call and response activity to begin with, and she also retells the story associated with their language lesson as she does this. At the beginning of each session, she establishes the language with the group and the focus of the activity. During the last session, the children were encouraged to make up their own stories. The teacher asks the children a number of questions and prompts them to expand on their story. She ensures that each student contributes to the story in some way by asking them to expand the story or by asking them to pick a picture to add to the Bee-Bot mat. During the last session, the children rely on the teacher's support. The teacher repeats the story each time to ensure the children stay on track.



	Day 1	Day 2	Day 3	Day 4	Day 5
Orange	40.26%	50.65%	49.23%	51.99%	40%
Green	28.89%	36.21%	30.54%	49.37%	48.72%
Yellow	29.21%	35.29%	35.32%	51.21%	
Purple	20.30%	43.96%	49.38%		

Figure 26 Percentage of the teacher's language use in Irish (Day 1-5)

The teacher on day one of the activity with each group is observed and recorded using more English as the language of instruction to establish the activity with the children and to ensure a common understanding amongst the group. The highest percentage of Irish (40.26%) was used with the orange group, and the lowest percentage (20.30%) was used with the purple group. A rationale for this could be that English is the medium of instruction in the school the children are not familiar with being immersed in another language. This is also a new activity for the children, and the teacher needs to set up the activity and ensure that the children understand how to use the Bee-Bot and the linkage between the activity and their Irish language lessons. The children hear Irish in an informal manner throughout the day, but aside from their Irish language lesson, they do not participate in any other subject areas through Irish. As the sessions with each group progress, the teacher begins to use more Irish words, and there is a reduction in her use of English. The teacher's language use overall decreases as the children take ownership of the activity and support each other.

7.3.6.1 Linking back to English to confirm comprehension Green group day 3

*TEA: An uair seo tá Bee-Bot ag tógáil teach tuí, tuí.
*TEA: Can you remember which one is the teach tuí?
*CH1: 0[% Points to teach brice].
*TEA: No thats the teach brící.
%act: Points to relevant picture.
*TEA: This is teach adhmad and this is teach tuí.
%act: Points to relevant picture.
*TEA: Whats tuí?
*TEA: What does it mean in English?
*CH1: Straw.
*CH6: Straw.
*CH3: Straw.
*TEA: Straw.
*TEA: Yeah straw.
*TEA: So tá Beebot ag tógáil teach tuí.

7.3.6.2 Giving instructions Greep group day 3

*TEA: So, Ethan do you know what youre going to do.
*CH1: Yeah.
*TEA: Youre going to give her an instruction and shes going to move Beebot so you might say is maith liom uisce or is maith liom sú oráiste or is maith liom mac tíre.
*CH6: 0[% presses x].
*CH1: Eh ól I said.
*TEA: Oh, tá mé ag ól ar fheabhas.

This section gave a detailed overview of the activity for the orange group. This group was one of two groups to complete five days of the activity. A brief overview was provided for the other three groups. This section provided the total social and target language use for the group and also provided a review of the total language use from each child, which also included directional language. While directional language was used on some days of the activity, the social and target language were the focus of the analysis.

7.4 Computational thinking skills

This section will present the results for CT skill development over the six-week research intervention in a junior infant classroom (age 5-6). This section will look at the children that participated in the activity and the number of tasks they were encouraged to undertake in each session. A review of the complexity of each task undertaken and the metric used to measure complexity for these tasks is provided. Findings will be presented in the order of whole class CT skills observed, followed by a short case study review of the orange group's development over the six-week intervention.

7.4.1 Assigning tasks

As outlined previously, the number of children in attendance varied across the days for a number of reasons. During some of the sessions, all the children were in attendance, but some children were not assigned any tasks. This is outlined in below**.** (* indicates present but no tasks completed)

Table 18 Children present across each day

Child	Day 1	Day 2	Day 3	Day 4	Day5
OC1	✓	✓	✓	X	✓
OC2	✓	✓	✓	✓	✓
OC3	✓	✓	✓	✓	✓
OC4	✓	✓	✓	✓	✓
OC5	✓*	✓	✓	✓	✓
GC1	✓	✓	✓	✓	✓
GC2	✓	✓	X	✓	✓
GC3	✓	✓	✓	✓	✓
GC4	✓	✓	✓	X	✓
GC5	✓	✓	✓	✓	✓
GC6	X	✓	✓	✓	✓
YC1	✓	✓	✓	✓	X
YC2	✓	X	✓*	✓	X
YC3	✓	✓	✓*	X	X
YC4	✓	✓	✓	✓	X
YC5	✓	✓	✓	✓	X
PC1	✓	✓	✓	X	X
PC2	✓	✓	✓	X	X
PC3	✓	✓	✓	X	X

PC4	✓	X	X	X	X
PC5	✓	✓	✓	X	X

On Day 3, for example two children from the yellow group did not complete any tasks as they were taken for reading sessions during the Bee-Bot activity. While they did return to the activity on the day, they chatted to the other children and observed others as they completed their tasks.

While the teacher reminded the group at the beginning of the activity session that each member of the group was to complete a task, this did not always happen. An example of this was on day one, one child from the orange group was not assigned any tasks by their peers. This child played with the support cards but did not engage with the Bee-Bot activity. While the teacher had set up the activity with a number assigned to each child, they tried to follow this sequence (Appendix M). As she had to leave to assist other group activities, the children were observed losing track of the sequence and skipping over some children. It was apparent upon the teacher’s return to the group that she assumed everyone in the group had participated, but she was unaware that one child had not. This child did not seem bothered by this in any way, as she was happy to play with the support materials.

7.4.2 Tasks

During the six-week intervention, the children were actively engaged in the Bee-Bot activity, which involved following a predetermined route on the Bee-Bot mat. This route was dictated by the stories they had previously heard in their Irish language lessons. The Bee-Bot mat was designed with pictures representing key elements of the stories, creating a visual and interactive experience for the children. Throughout the intervention, the children followed three different stories during the Bee-Bot activity: "Teidí sa pháirc" (Teddy at the park), "Bia" (Food), and "Na Trí Mhuicín" (The Three Little Pigs). These stories served as the foundation for the Bee-Bot routes, and the children had the opportunity to explore and interact with the narratives through the movement of Bee-Bot on the mat.

Days four and five of the activity saw an extension of the storytelling approach. The teacher allowed the children to engage their creativity by crafting their own unique stories using the pictures from the previous stories as well as adding their own created images to the Bee-Bot mat. This expansion empowered the children to take ownership of the activity and fostered their imagination and storytelling skills. To guide the children through the activity, the teacher would break down each story into individual tasks for

Bee-Bot. Each line of the story represented a specific task that Bee-Bot had to accomplish. For instance, if the story mentioned Bee-Bot starting at the picture of Teddy and needing to reach the park, one child would be assigned the task of programming Bee-Bot to move from one picture to the other. In this way, the children's sequencing, problem-solving, and coding skills were honed. The instruction and communication during the activity were conducted through Irish and sometimes English by the teacher, further reinforcing the children's language proficiency in a practical and enjoyable context. The children actively listened to the teacher's Irish instructions and extracted the essential information to plot Bee-Bot's route on the mat.

Throughout the activity, the teacher assumed a supportive role without explicitly telling the children how to reach their destination. Instead, she only disclosed the next line of the story and the subsequent location Bee-Bot was meant to visit. This approach encouraged the children to think critically and collaboratively, devising their unique routes to complete each task. For data analysis purposes, the researcher recorded the routes the children took when fulfilling each task. The initial direction Bee-Bot moved (left, right, forward, or backward) was logged, and subsequently, the shortest route to the destination was calculated. This data provided valuable insights into the children's problem-solving strategies and how they navigated Bee-Bot through the challenges posed by the tasks. The number of tasks assigned to the children varied across each group and each day. Some children had more opportunities to interact with Bee-Bot and complete more tasks than others. This variation arose from several factors: the length of the activity was directly related to the story being followed, so if the story concluded with Bee-Bot reaching its final destination, there were no further tasks. Additionally, when the teacher stepped back to allow the children to work together as a group, the traditional order for taking turns was disrupted and changed. While the teacher was working with the group they skilfully differentiated tasks for specific children. This involved making adjustments to the storytelling process or deviating from the assigned sequence of children to choose the next participant at random. This approach ensured that each child had a fair chance to participate and contribute to the activity, catering to their individual needs and abilities.

On average, each child completed three tasks on day one of the activity and two tasks on days two, three, four, and five. This data showcased how the children's engagement and participation evolved over the duration of the intervention. The Bee-Bot activity, coupled with storytelling and language learning, provided a holistic learning experience for the children. It not only enhanced their language skills but also nurtured critical thinking, problem-solving, and collaborative abilities as they embarked on imaginative journeys with Bee-Bot on the mat.

Table 19 Number of tasks per child each day

Child	Day 1	Day 2	Day 3	Day 4	Day5
OC1	2	2	1	X	2
OC2	1	2	2	2	2
OC3	2	2	1	2	2
OC4	2	2	1	2	2
OC5	0	2	2	3	2
GC1	3	3	2	2	2
GC2	2	2	X	1	1
GC3	4	2	2	2	2
GC4	4	3	2	X	2
GC5	3	2	2	3	2
GC6	X	2	2	1	2
YC1	3	2	3	2	X
YC2	3	X	0	2	X
YC3	2	2	0	X	X
YC4	2	3	4	1	X
YC5	3	3	3	2	X
PC1	3	2	2	X	X
PC2	4	4	2	X	X
PC3	3	2	2	X	X
PC4	6	X	X	X	X
PC5	2	2	2	X	X
Average	3	2	2	2	2

7.4.3 Skills analysis

7.4.3.1 Abstraction

In this study, the initial analysis focused on assessing the cognitive skill of abstraction, as explained in section 3.3. Abstraction refers to the ability to determine which information about an entity or object is essential to retain and which can be disregarded (Wing, 2011). The researcher measured abstraction in two primary ways: through language usage and the children's interactions with the Bee-Bot. Language played a central role in the observational findings. As the children engaged in the Bee-Bot activity, they communicated with their teacher and with each other using the Irish language. This linguistic aspect allowed the researcher to identify instances where the children demonstrated abstraction skills. They could discern what information was crucial for setting Bee-Bot's route and completing the task at hand, and what parts of the conversation were unnecessary. The children exhibited the capacity to focus on key words and target language that were most relevant to programming Bee-Bot and achieving their objectives.

During the activity, some children were observed repeating specific key words and phrases that played a vital role in guiding Bee-Bot's movements. By doing so, they demonstrated their ability to abstract essential instructions and omit extraneous details, honing their problem-solving and language skills in the process. The use of Irish language further emphasised their cognitive engagement and active participation in the activity.

Overall, the analysis of abstraction in this study highlighted the children's capacity to selectively extract and utilise pertinent information from their language interactions, both with the teacher and with their peers, to effectively engage with Bee-Bot and accomplish their assigned tasks. This cognitive skill was instrumental in their successful navigation of Bee-Bot on the mat and in fostering their language development in an immersive and meaningful context.

Table 20 Computational Thinking Skills analysis: Abstraction

Computational Thinking Skills				
Abstraction	Orange	Green	Yellow	Purple
Day 1	CH1: 4 $ABS:LANG CH3: 2 $ABS:LANG CH4: 1 $ABS:LANG	CH1: 1 $ABS:BOT CH1: 2 $ABS:LANG CH4: 1 $ABS:BOT CH5: 2 $ABS:LANG	CH1: 2 $ABS:LANG CH2: 1 $ABS:LANG CH5: 1 $ABS:LANG	CH1: 3 $ABS:LANG CH1: 1 $ABS:BOT CH3: 3 $ABS:LANG CH4: 3 $ABS:LANG CH4: 1 $ABS:BOT
Day 2	CH3: 3 $ABS:BOT CH3: 3 $ABS:LANG		CH1: 1 $ABS:LANG CH3: 2 $ABS:LANG CH4: 1 $ABS:LANG CH5: 1 $ABS:BOT CH5: 1 $ABS:LANG CH6: 2 $ABS:LANG	CH1: 1 $ABS:LANG
Day 3	CH1: 2 $ABS:LANG CH2: 3 $ABS:LANG CH3: 2 $ABS:LANG CH5: 3 $ABS:LANG	CH1: 1 $ABS:LANG CH6: 2 $ABS:LANG	CH2: 1 $ABS:LANG CH5: 2 $ABS:LANG	
Day 4	CH1: 2 $ABS:LANG CH2: 1 $ABS:LANG CH3: 1 $ABS:LANG CH4: 3 $ABS:LANG CH5: 2 $ABS:LANG		CH1: 4 $ABS:LANG CH2: 1 $ABS:LANG CH5: 1 $ABS:LANG	
Day 5	CH: 1 $ABS:LANG CH3: 1 $ABS:LANG CH4: 2 $ABS:LANG	CH1: 2 $ABS:BOT CH3: 1 $ABS:BOT CH3: 1 $ABS:BOT CH4: 1 $ABS:BOT CH5: 2 $ABS:BOT		

7.4.3.2 Generalisation

As per the Angeli et al. 2016 CT curriculum framework, generalisation involves recognising common patterns between older and newer problem-solving tasks and utilising previously employed sequences of instructions to solve new problems. However, in the context of this study, it was challenging to identify the skill of generalisation for task completion during the Bee-Bot activity due to its specific design.

The activity was structured in a way that each child was assigned different tasks, and they rarely repeated the same task unless they made a mistake and tried to correct it. This repetition for correction, termed "debugging," did not fulfill the definition of generalisation, as it involved rectifying specific errors rather than applying previously acquired strategies to new problems.

Though there were a few instances of generalisation identified during the activity, they were not directly related to task completion. Instead, these examples pertained to language generalisation. The children were observed recognising patterns in the Irish language from their language lessons and incorporating them into their interactions during the Bee-Bot activity.

It is important to note that while language generalisation was observed, it was not a significant finding for CT skills development in this particular study due to the lack of recurring pathways for Bee-Bot.

Table 21 Computational Thinking Skills analysis: Generalisation

Generalisation	Orange	Green	Yellow	Purple
Day 1				
Day 2	CH3: 1 $GEN:LANG	CH1: 2 $GEN:LANG CH6: 1 $GEN:LANG		
Day 3				
Day 4				
Day 5				

7.4.3.3 Decomposition

During the activity, the teacher gave the children the opportunity to attempt their assigned task a number of times until completion. With each attempt to complete a task, the child was exercising their debugging skills as they adjusted their command input each time. During these attempts, the teacher and the other children in the group scaffolded the child who was inputting the commands through verbal and physical cues.

They indicated the route verbally in Irish using directional language and physically by placing their hands on the mat to show the route for Bee-Bot to follow. The children can also be seen scaffolding themselves by using one hand to plot their route and the other hand to input the commands. Private speech (Section 2.2.2.1) was also observed in some cases where the child is talking quietly through the process and developing a decomposition strategy or breaking down the task into a shorter sequence.

Table 22 Computational Thinking Skills analysis: Decomposition

Decomposition	Orange	Green	Yellow	Purple
Day 1		CH3 1 $DEC:LANG CH5: 1 $DEC:LANG CH4 1 $DEC:LANG	CH1: 2 $DEC:BOT CH5: 5 $DEC:BOT	CH3: 2 $DEC:BOT
Day 2	C2: 1 $DEC:BOT CH3: 2 $DEC:LANG CH3: 1 $DEC:BOT			CH1: 4 $DEC:BOT CH5: 1 $DEC:BOT
Day 3	CH5: 2 $DEC:BOT		CH5: 1 $DEC:BOT	CH1: 2 $DEC:BOT
Day 4	CH2: 1 $DEC:BOT CH3: 1 $DEC:LANG	CH4: 2 $DEC:BOT CH5: 2 $DEC:BOT	CH2: 1 $DEC:BOT CH2: 1 $DEC:LANG	
Day 5	C2: 1 $DEC:LANG CH2: 1 $DEC:BOT CH3: 1 $DEC:BOT	CH5: 1 $DEC:LANG CH6: 1 $DEC:BOT		

7.4.3.4 Algorithmic thinking

Algorithmic thinking was measured by the child using a “defined series of steps for a solution and putting instructions in the correct sequence” (Angeli et al., 2016). Each task varied in length and difficulty as it was always dependent on the next line of the story that the children were focusing on. In this way the children had a variety of tasks to complete which included long sequence to short sequences therefore the complexity of each task was varied. Task complexity was measured in two ways:

The first method of measurement was by the number of commands the child needed to input for Bee-Bot to complete the route. The commands include x to clear all previous commands, forward (15cm), backwards (15cm), right and left (90 degrees) and Go (to execute the series of commands). With each line of the story, the complexity varied depending on where the next picture was on the mat and the direction in which Bee-Bot was facing. The children were not allowed to physically turn Bee-Bot they had to input the command to turn it around to suit the direction in which it needed to go.

The second method of measurement was establishing a complexity value for each task which accounts for the difficulty level which turning represented for the children. A value of 1 was assigned to the commands x, forward, backwards and go due to the ease at which children could execute them, and a score of 2 was assigned to right and left commands as they represented a more significant spatial awareness challenge for young children.

Table 23 Computational Thinking Skills analysis: Algorithmic thinking

Algorithmic thinking	Orange	Green	Yellow	Purple
Day 1	CH2: 3 $ALG: BOT CH3: 2 $ALG: LANG CH4: 5 $ALG: BOT CH3: 6 $ALG: BOT	CH1:3$ALG: BOT, CH1: 1 $ALG: LANG CH3: 2 $ALG: BOT CH4 4 $ALG: BOT CH5:4 $ALG: BOT	CH1: 9 $ALG: BOT CH2: 5 $ALG: BOT CH3: 3 $ALG: BOT CH4: 7 $ALG: BOT CH5:15$ALG: BOT	CH1: 4 $ALG: BOT CH2: 8 $ALG: BOT CH3: 8 $ALG: BOT CH4: 14 $ALG: BOT
Day 2	CH1: 8 $ALG: BOT CH2: 3 $ALG: BOT CH3: 4 $ALG: BOT CH4: 3 $ALG: BOT CH5: 3 $ALG: BOT	CH1: 3 $ALG: BOT CH2: 3 $ALG: BOT CH3: 4 $ALG: BOT CH4: 8 $ALG: BOT CH5: 2 $ALG: BOT CH6: 4 $ALG: BOT	CH1: 2 $ALG: BOT CH3: 6 $ALG: BOT CH4: 6 $ALG: BOT CH5: 7 $ALG: BOT CH6: 7 $ALG: BOT	CH1: 8 $ALG: BOT CH2: 9 $ALG: BOT CH3: 4 $ALG: BOT CH5: 3 $ALG: BOT
Day 3	CH1: 3 $ALG: BOT CH2: 1 $ALG: LANG CH2: 2 $ALG: BOT CH3: 2 $ALG: BOT CH4: 1 $ALG: BOT CH5: 8 $ALG: BOT	CH1: 2 $ALG: BOT CH2: 3 $ALG: BOT CH3: 3 $ALG: BOT CH4: 6 $ALG: BOT CH5: 3 $ALG: BOT CH6: 2 $ALG: BOT	CH1: 6 $ALG: BOT CH4: 9 $ALG: BOT CH5:12 $ALG: BOT	CH1: 5 $ALG: BOT CH2: 5 $ALG: BOT CH5: 7 $ALG: BOT
Day 4	CH2: 6 $ALG: BOT CH3: 1 $ALG: BOT CH4: 5 $ALG: BOT CH5: 6 $ALG: BOT	CH1: 2 $ALG: BOT CH2: 1 $ALG: BOT CH3: 7 $ALG: BOT CH4: 8 $ALG: BOT CH4: 1 $ALG: LANG CH5: 4 $ALG: BOT	CH1: 7 $ALG: BOT CH2: 6 $ALG: BOT CH4: 3 $ALG: BOT CH5: 4 $ALG: BOT	
Day 5	CH1: 6 $ALG: BOT CH2: 3 $ALG: BOT CH3: 3 $ALG: BOT CH4: 3 $ALG: BOT CH5: 4 $ALG: BOT	CH1: 3 $ALG: BOT CH2: $ALG: BOT CH3: 3 $ALG: BOT CH4: 3 $ALG: BOT CH5: 5 $ALG: BOT CH6: 5 $ALG: BOT		

From these two measurements, task complexity is measured in both the number of commands in a task and the c-value of the task. An example of this can be seen in Table 28, which shows the increase in complexity value from the number of commands to the c-value. Looking at OC3 in Table 28, we see the task that the child was assigned involved inputting ten commands, and there were two turns in this sequence; therefore, the c-value is 12.

Table 24 Orange group Day 2 Task 1 commands and c-value

	Orange group Day 2 Task 1	No of commands	Complexity value
OC1	x forward forward forward left forward go	7	8
OC2	x backwards backwards backwards backwards backwards left forward go	9	10
OC3	x left backwards backwards backwards backwards backwards left forward go	10	12
OC4	x forward left forward forward forward go	7	8
OC5	x forward go	3	3

7.4.3.5 Debugging the task

The number of attempts to debug a task varied for each child. Along with the child's capacity to visualise the tasks and their CT skill development, there were three main factors identified from the video footage that impacted the number of attempts taken for each task. The first was the number of commands within the task and the level of difficulty associated with the tasks, i.e., if there were multiple turns included in the route. The second factor was if the child forgot to press x. If the child did not press x, the commands they had inputted along with the commands from the previous task were executed by Bee-Bot. This had a significant impact on one child in the orange group on day five, whereby the task was three commands in total, but it took four attempts to complete it as the child forgot to press x. The third factor was the assistance of others in the group. While they attempted to support children in their completion of a task, they sometimes confused the child more.

The children were however identified as supporting themselves with debugging a task. They used physical movements with their hands to plot the route before coding it, they used one hand to step or plot the route as they coded with the other and they used verbal reasoning to figure out the issue with their task.

The next section will present an overview of all children's progression in relation to task complexity and their attempts per task.

Table 25 Computational Thinking Skills analysis: Debugging

Debugging	Orange	Green	Yellow	Purple
Day 1	CH3: 1 $DEB: LANG CH3: 1 $DEB: BOT	CH3 1 $DEB: LANG	CH1: 2 $DEB: BOT CH2: 1 $DEB: BOT CH3: 1 $DEB: BOT CH4: 4 $DEB: BOT CH5: 4 $DEB: BOT	CH1: 1 $DEB: BOT CH2: 1 $DEB: BOT CH3: 3 $DEB: BOT CH4: 4 $DEB: BOT
Day 2	CH2: 2 $DEB: LANG CH3: 1 $DEB: LANG CH4: 2 $DEB: BOT	CH1: 1 $DEB: BOT CH1: 1 $DEB: LANG CH2: 1 $DEB: BOT CH3: 1 $DEB: BOT CH4: 1 $DEB: BOT CH5: 1 $DEB: BOT CH6: 1 $DEB: LANG	CH4: 1 $DEB: BOT CH5: 3 $DEB: BOT CH6: 4 $DEB: BOT	CH1: 2 $DEB: BOT CH2: 1 $DEB: BOT CH3: 2 $DEB: BOT CH5: 1 $DEB: BOT
Day 3	CH1: 1 $DEB: LANG CH3: 1 $DEB: LANG CH5: 1 $DEB: BOT	CH1: 1 $DEB: LANG CH2: 1 $DEB: BOT CH3: 1 $DEB: BOT CH4: 3 $DEB: BOT	CH1: 2 $DEB: BOT CH4: 3 $DEB: BOT CH5: 8 $DEB: BOT	CH1: 1 $DEB: BOT CH2: 1 $DEB: BOT CH5: 4 $DEB: BOT
Day 4	CH2: 1 $DEB: BOT CH4: 1 $DEB: BOT	CH4: 1 $DEB: BOT CH5: 1 $DEB: LANG	CH1: 5 $DEB: BOT CH2: 3 $DEB: BOT CH4: 2 $DEB: BOT CH5: 1 $DEB: BOT	
Day 5	CH2: 1 $DEB: BOT CH4: 1 $DEB: LANG CH4: 1 $DEB: BOT	CH1: 1 $DEB: BOT CH3: 1 $DEB: BOT CH4: 1 $DEB: BOT CH5: 2 $DEB: BOT CH6: 3 $DEB: BOT		

7.4.4 Task analysis

An analysis was completed on the average number of attempts per child where the commands were bucketed. This analysis gave an overall view that the number of attempts per task reduced over the six-week research activity. The tasks the children undertook were of varying length, and so further data filtering was undertaken. The tasks were filtered by a metric of easy, medium, and hard. The values for these are shown in Table 29. The measurement for these were easy (three or fewer commands); medium (four- 6 commands) and; hard (seven or more commands). On day one, across all groups, we see that 16 tasks that the children undertook included seven or more commands and 28 tasks were between 4 and 6 commands. The number of harder tasks increased over a five-day period.

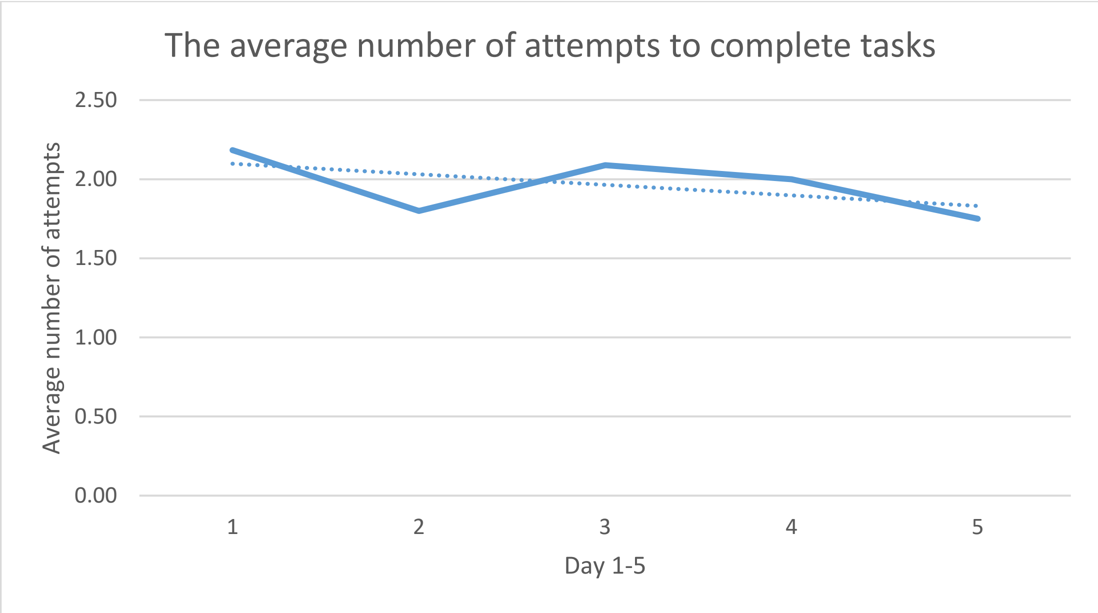


Figure 27 Mean of attempts where commands are bucketed

The number of tasks in Table 29 that are less than 3, there are no tasks that have less than three commands on days three, four, five. Many tasks are split between 4-6 commands and seven or more commands. Reviewing the proportion of total tasks that are harder tasks (7 or more commands) over the five days, we see that the number of tasks the children are undertaking overall is within the harder category (Figure 22). The results outline that the overall average of the attempts by the children is improving across all tasks, and we see that the tasks are becoming increasingly complex across the five days.

Table 26 Bucket values of tasks - easy, medium and hard

Bucket value	Mean of attempts where commands are bucketed	Mean of attempts where complexity is bucketed	Count of tasks with commands
Day 1			
Easy (3 or less)	1	1	2
Medium (Between 4 and 6)	1.8	1.5	28
Hard (7 or more)	3	2.8	16
Total	**2.2**	**2.2**	**46**
Day 2			
3 or less	1	1	2
Between 4 and 6	1.7	1.6	17
7 or more	2.0	1.9	18
Total	**1.8**	**1.8**	**37**
Day 3			
3 or less	n/a	n/a	0
Between 4 and 6	1.9	1.7	15
7 or more	2.2	2.3	16
Total	**2.1**	**2.1**	**31**
Day 4			
3 or less	n/a	n/a	0
Between 4 and 6	1.6	1.4	12
7 or more	2.4	2.3	11
Total	**2**	**2**	**23**
Day 5			
3 or less	4	4	0
Between 4 and 6	1.3	1.3	8
7 or more	1.9	1.8	10
Total	**1.8**	**1.8**	**18**

Reviewing the number of attempts the children take on the harder tasks over five days, we see a significant decrease. While the tasks are getting harder as indicated in Figure 22, the children are making fewer attempts to complete the tasks. This represents an improvement in their computational skill development. Complexity: number of steps average graphs c-value

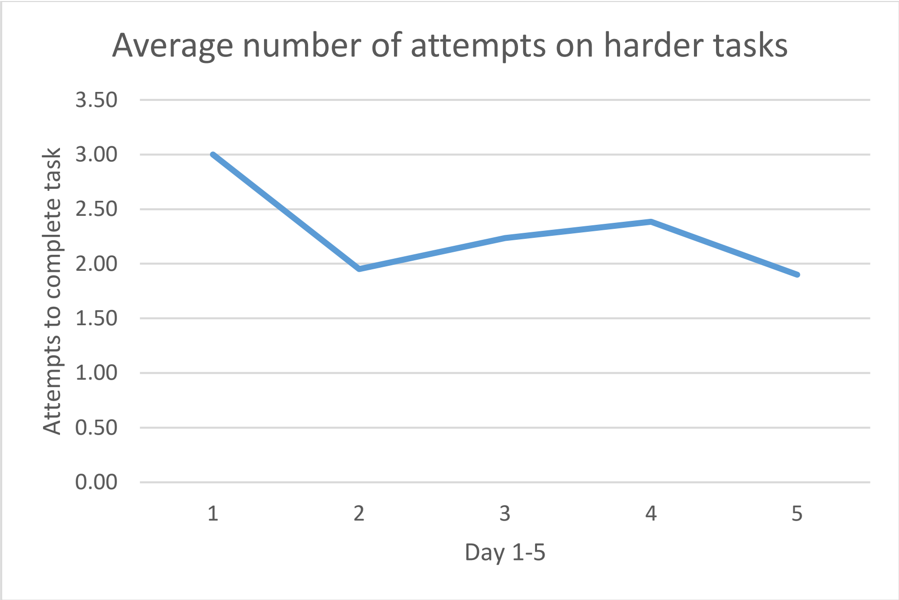


Figure 28 Mean of attempts where commands (7 or more) are bucketed

7.4.5 Orange group

This section will look at one of the groups to give a more in-depth look at the results for the CT skill development. This section will look at the overall development of the group and then present some examples of CT skills that were identified in the video footage. Of the four groups that participated in the research intervention only two groups completed five days of the research activity, the orange group was one of them.

From Table 30, the number of tasks the children undertook varied, with all children who were present completing at least one task each day except for OC5, as mentioned previously (Appendix U). Some children completed two tasks, and one child completed three tasks on day 5.

Table 27 Orange group results

		Day 1			Day 2			Day 3			Day 4			Day 5		
Task 1	Child	No of commands	C-value	No of attempts	No of commands	C-value	No of attempts	No of commands	C-value	No of attempts	No of commands	C-value	No of attempts	No of commands	C-value	No of attempts
	OC1	5	6	1	7	9	2	11	12	2				3	3	4
	OC2	9	10	2	9	10	2	5	5	1	8	9	3	8	11	2
	OC3	10	12	4	10	12	1	6	7	2	7	8	1	6	7	2
	OC4	6	7	1	7	8	1	7	9	2	4	4	2	7	8	1
	OC5				3	3	1	9	11	2	4	4	1	4	4	1
Task 2	OC1	8	9	3	11	12	2							6	6	1
	OC2				10	12	1	7	9	1	6	7	1	6	7	1
	OC3	5	5	1	9	11	2				6	7	1	7	8	1
	OC4	6	7	2	7	9	2				8	9	2	7	8	2
	OC5				3	3	1	7	8	2	7	9	2	8	10	1
Task 3	OC1															
	OC2															
	OC3															
	OC4															
	OC5													4	4	1

Across Table 30, the children need fewer attempts at a task from day 1 to day 5. On day one, OC3 has a task that is ten commands in length and has a c-value of 12. It takes this child four attempts to complete this task; however, on day two, when asked to complete a similar task of the same length and c-value, the child takes one attempt to complete it. This level of progression can be seen across this group as it takes the children between one and two attempts to complete their tasks. There is one outlier on day 5. OC1 was given a task with three commands which have been categorised as an easy task. However, it took this child four attempts to complete this task. This child forgot to input the x command, and so the child took an additional three attempts to get Bee-Bot to its destination. This group was identified as using a number of CT skills throughout their five days. Some of those skills, along with SCT constructs, are identified in the following example. OC2 took three attempts to complete a task on day four. From this example, we see the support the teacher offers OC2, the language used and also the support and observations from OC3.

**TEA: OC2 cur Bee-Bot go dtí an carr.*
**OC2: How do I do?*
**TEA: Well, maybe you could get Bee-Bot to go siar siar cas and then ar aghaidh ar aghaidh ar aghaidh?*
%sct: SCA: TEA

**OC2: Yeah.*
**TEA: So brú x ar dtús.*
**OC2: But what if I go over there.*
**OC3: You won't go over there.*
%sct: SCA: CHI
**TEA: You won't.*
**OC2: 0[% presses backwards, go].*
%comp:ALG:BOT
**OC3: Oh no.*
**OC3: Oh my god.*
**TEA: Just leave it.*
**TEA: Ok so brú x ar dtús.*
**TEA: Sorry CH2.*
**OC2: Maybe it's because I didn't do this one.*
%act: pointing to x.
%comp:DEB:BOT
**OC2: 0[% presses backwards, backwards, counts out spaces and direction, backwards].*
%comp:ALG:BOT
**TEA: So, watch did you cas?*
**OC3: No, he didn't.*
**TEA: Ok so brú x.*
%sct: SCA: TEA
**OC2: 0[% presses x].*
**TEA: Siar.*
%sct: SCA: TEA
**OC2:0[% presses backwards, backwards].*
**TEA: Now you need to cas.*
%sct: SCA: TEA
**OC2:0[% presses left].*
**TEA: And now ar aghaidh.*
%sct: SCA: TEA
**OC2:0[% presses backwards].*
**TEA: Now you're here so you need to ar aghaidh.*
**OC3: Ar aghaidh.*
%act: Pointing to the button.
%sct: SCA: CHI
**TEA: Ar aghaidh yeah OC3 has it.*
**OC2:0[% presses forward].*
%comp:ALG:BOT
**TEA: Yeah, agus arís.*
%act: Pointing to the picture where Bee-Bot would be.
%sct: SCA: TEA
**OC2:0[% presses forward, forward, forward].*
%comp:ALG:BOT
**TEA: Agus brú go.*
**OC2:0[% presses go].*
%comp:ALG:BOT
**OC2: That was one of our tricky ones.*
**OC3: It's going to go that way and then that way.*
%comp:DEC:LANG
**OC2: No, you see.*
**OC3: Yay.*
**OC3: Yay.*

Figure 24 Script sample - algorithmic thinking and debugging skills

OC2 from this example displays algorithmic thinking along with debugging skills in the example above. Through language used in the activity, abstraction and decomposition are also identified during the tasks. The children are given the instructions for the tasks in Irish, and they must abstract from these instructions the most relevant information for the tasks. In the example below, we see the teacher tells the next line of the story from the three little pigs. She leaves the last part of it as a question for OC2. OC2 answers by pointing to the relevant picture, the pot of hot water. The child begins to code and hesitates; the teacher acknowledges this hesitation by advising the child on the next turn. This is common practice for the teacher across the groups. OC3 also scaffolds the child by pointing to the next steps on the mat for the OC2. As the teacher advises OC2 to '*press go*' and see what happens, OC2 repeats this "Just go here and we will see". OC2 is observed here breaking down the task acknowledging a step-by-step method which is logged as decomposition.

```
*TEA:	Téann sé suas an simléar agus tagann sé síos an simléar and what does he go into when he goes síos an simléar?
*CH2:	0[% Tommaso points at the pot].
%comp:ABS:LANG
*TEA:	Ar fheabhas Tommaso cur Bee-Bot go dtí an pota uisce te.
*TEA:	Can you do that?
*CH2:	Yeah.
*TEA:	Try put Bee-Bot to the pota uisce te.
*CH5:	He's scared cause it's so hot.
%comp:ABS:LANG
*TEA:	It's te is not it.
*CH2:	0[% presses x left].
%comp:ALG:BOT
*TEA:	Go ar chlé arís.
*CH2:	0[% Tommaso hesitates].
*TEA:	You've got him ar aghaidh and go ar chlé arís oh no wait sorry go ar
	aghaidh.
*CH3:	0[% OC3 points to the steps to help].
%sct:	SCA: CHI
*CH2:	0[% presses forward, forward, forward].
%comp:ALG:BOT
*CH3:	Now go.
*TEA:	Press go, and we will see where he gets to.
*CH2:	0[% presses go].
%comp:ALG:BOT
*CH2:	Just get here, and we will see.
%comp:DEC:LANG
```

Figure 25 Orange group day 2

This section reviewed the results of the CT skills analysis in this research intervention. It highlighted each skill, an analysis of the tasks assigned to the children and a review of the orange group's developments. The next section will look at the teacher's perspective of the research intervention.

7.5 Children's attitudes to the research intervention

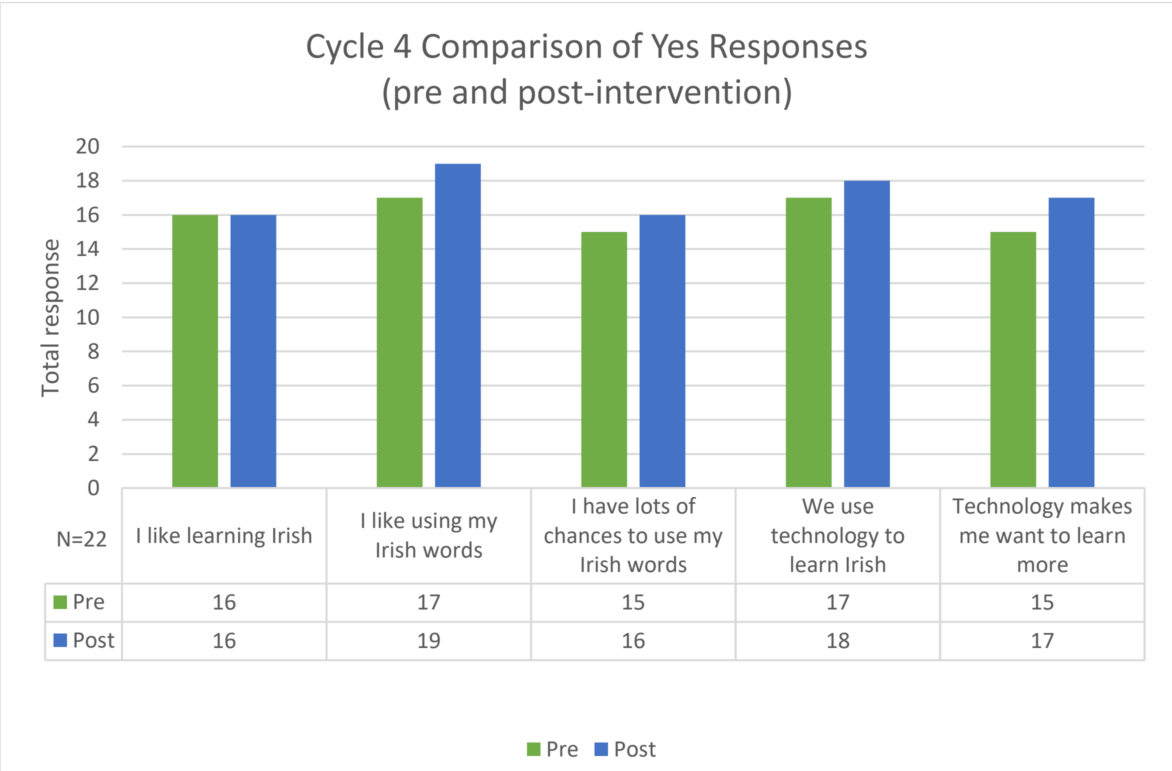
Gathering the children's perspectives on the intervention was an important part of this study.

As highlighted in section 4.6.4, the inclusion of child voice in research with young children is essential for promoting ethical practices, improving the quality and relevance of research, and empowering children to participate in decisions that affect their lives. While questionnaires and focus groups with a young cohort of participants can present some challenges (4.6.4) they are an important part of acknowledging and including children's voices within research (Alderson & Morrow, 2011). Children's opinions were gathered before and after this intervention to understand their outlook on learning Irish and the use of robotics for learning Irish. This section presents the results from the pre and post activity questionnaires as well as thematic analysis results from the focus groups conducted with the children. The approach taken to the focus group is outlined in section 4.8.4 and the principles of thematic analysis in section 4.9.4.

7.5.1 Questionnaires

7.5.1.1 Pre-intervention questionnaire (Appendix G)

The children answered five questions that focused on learning and using the Irish language and what they thought about using technology as well. The response from the children overall marginally increased from pre-intervention to post intervention. The response to one question stayed the same "I like learning Irish," with 16 children responding yes before and after the intervention. While the data collected from the questionnaire was limited, it provided an opportunity to discuss the research with the children and the importance of their voice and opinion during new activities. As previously outlined in section 4.6.4, the social desirability factor became apparent as the children were answering the questionnaires. It was noted by the classroom teacher and the researcher that some children were influenced by their peers when answering the questions.



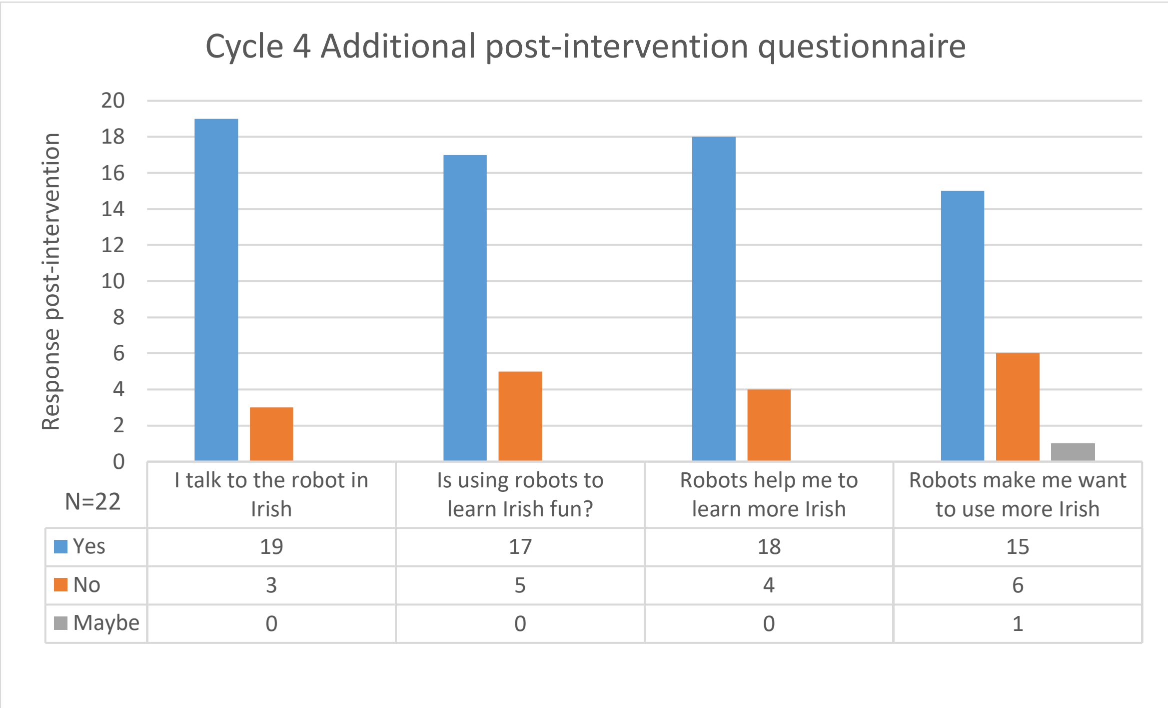
N=22	I like learning Irish	I like using my Irish words	I have lots of chances to use my Irish words	We use technology to learn Irish	Technology makes me want to learn more
Pre	16	17	15	17	15
Post	16	19	16	18	17

Figure 29 Cycle 4 Comparison of positive answer pre and post-intervention

7.5.1.2 Post-intervention questionnaire (Appendix H)

The post-intervention questionnaire included an additional four questions related specifically to robotics. Having established through the activity what robotics meant, the children answered questions based on their use of Bee-Bot along with Irish. The response to this set of questions was positive, with an average of 17.25 responses indicating yes. The fourth question, "*robots make me want to use more Irish*," received the highest number of no responses and one maybe response. It was noted during this question by the teacher and the researcher that the wording of the question confused some children, and it was reiterated by both in a number of different ways to support the children's understanding of the statement. Post-intervention the majority of children indicated a positive outlook towards the robotics activity and learning Irish.

The word technology presented an issue for some children, and further elaboration was required. While the children were responding to the questionnaires, both the researcher and the teacher noticed that some children appeared to be influenced by others and how they answered the questions. This behaviour was also identified during the pilot cycles.



N=22	I talk to the robot in Irish	Is using robots to learn Irish fun?	Robots help me to learn more Irish	Robots make me want to use more Irish
Yes	19	17	18	15
No	3	5	4	6
Maybe	0	0	0	1

Figure 30 Cycle 4 Additional post intervention questionnaire

7.5.2 Focus Groups

This section will present the thematic analysis of the focus groups during this cycle. The first section looks at the emerging themes of the data before exploring each of these themes along with their subthemes in more depth. An overview of the principal emerging themes in the focus groups can be seen in appendix T, this provides a visual indication of relative frequencies. It is important to note that the numbers in the figure refer to the total number of coded references for each theme. Each reference includes one child's input or a conversation between some of the children, which was coded under a theme. Therefore, the numbers are not a direct count of individual children's responses but are a general indication of the occurrence of each theme.

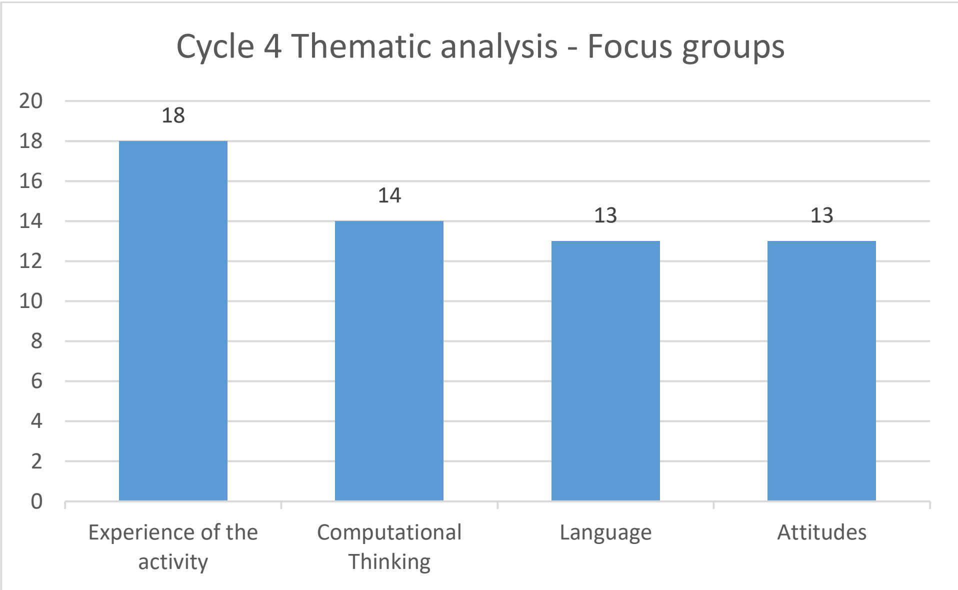


Figure 31 Cycle 4 Thematic analysis focus groups

The main focus of the discussion revolved around the activity with Bee-Bot. This included giving directions to Bee-Bot and addressing situations where the floor robot deviated from its intended path. The theme 'experience of the activity' had four subthemes: children's sense of ownership, the use of support structures, collaboration among participants, and the utilisation of a camera. There were two subthemes related to computational thinking: algorithmic thinking and debugging. The discussion will delve into these four primary themes, and a table containing relevant excerpts for each theme is provided in Appendix T.

7.5.2.1 Experience of the activity

There were various discussions with each of the focus groups where the children talked about the activity and the purpose of the activity. Many of the children linked the purpose of the activity to moving the Bee-Bot around the mat, and very few linked it to learning Irish. They did acknowledge, however, that they did the activity through Irish.

"CH3: We made up stories and stuff like that, and we did the Trí muicín story.
REA: Very good. And what language were you using when you were doing that?
CH3: As Gaeilge."

During the focus group, a reserved child expressed their perspective that the reason for moving Bee-Bot around the mat was primarily related to the presence of pictures. When questioned about how they would describe the activity and whether it could be considered a game in the Irish language, another child confidently stated that it could be called whatever one preferred. In response to a query about why they believed the activity was a game, one child explained that the inclusion of turn-taking and the freedom to choose between Bee-Bot and other activities were the factors that made it qualify as a game.

The activity itself took place during the play session, while the other children in the class were playing with other activities. The other children had free choice of activity during the time. One child commented on how he missed having this play session and wanted the Bee-Bot activity to be shortened. While he still enjoyed the Bee-Bot activity, he wanted to do it after he had a chance to play with the other activities.

REA: And tell me, is there anything you would like to change about this activity?
CH1: Make it shorter
REA: What do you mean shorter?
CH1: Cause like I don't like missing out on things. Like Aistear and stuff, cause that's our only playtime we really get
REA: So, you would like it to happen at a different time of day, so you didn't miss out on playtime
CH1: Yeah. I'd like to have it after Aistear."

A subtheme, which arose, was ownership of the activity or the ability to make a personal change to the activity. The groups had the opportunity to make different pictures for the Bee-Bot mat on their final day of the research activity.

CH2: And like we coloured in our own characters and made our own things, and they could be anything that you want, and we put them in the blank Bee-Bot mat. And if you say go to the unicorn, you go to the unicorn.

The children made up their own story to coincide with the pictures they had made for the Bee-Bot mat. Some of the children were very excited as they reflected on this during the focus group.

CH1: Yesterday we made up a new story the unicorn talked to muc the driver went to sleep on the trí muicín fell out of the car, the bought some sweets ice cream and and then they fell asleep on the road.
REA: So, tell me did you do that in English or in Irish?
CH1: Irish. They sleeped on the road.
CH2: Unicorn and trí muicín
REA: Unicorn trí muicín and they were in a
CH2: Carr
CH1: Unicorn talked so much the driver went to sleep, and they fell out the door, and there was sweets
REA: Thit siad amach an doras agus bhí siad ag ithe milseáin and seacláid
CH1: And smileys

During the six weeks, the children were offered a range of physical scaffolds to support their experience. The teacher introduced an A4 sheet and small playing cards. The children identified these scaffolds in the short video clip they watched at the beginning of the focus group. The children were asked about their effectiveness and whether they found them useful. Some children liked to use them, as can be seen from the video recordings; however, during the focus group, one child said they enjoyed the activity but not the support cards. While they stated that they enjoyed the activity, the small pictures were of no interest. This can be seen in the video footage; the children used them for a short time but were more likely to watch the Bee-Bot move across the floor mat.

CH1: Oh, oh, she's saying ar fheabhas to me
CH1: I can't believe that
CH1: Is that from the camera
REA: Yes, it is from the camera
REA: So, when you were putting all the instructions into Bee-Bot, was it really tricky to figure out ok "Teacher has asked me to go an pháirc;" was it really hard to imagine it and then put in the instructions?
Ch1: No, no, actually yeah, it was
REA: And did he get easier and easier as you went on
CH1: No
CH2: Yeah
CH1: No
REA: From day one until now
CH1: No
CH2: Yeah
REA: Was its great fun
CH1: No, it was not fun
REA: It was not fun, so you didn't like doing this
CH1: Yeah, I love doing that
REA: So which bit did you not like
CH1: The little pictures on the….

REA: Card ok

When asked whether they enjoyed doing the activity with their group, some children had differing responses. Some indicated that they preferred to do it by themselves as this gave them more time to engage directly with Bee-Bot, whereas, with a group, everyone had to take turns, as previously indicated in the activity response. Others indicated how they enjoyed the instruction part of the activity where they told each other where to send Bee-Bot on the mat.

REA: What was your favourite thing first?
CH3: Pressing the buttons and watching him move.
REA: And what did you think about doing it as a group?
CH3: I liked doing it with all my friends and stuff.
REA: Ok, and did your friends instruct you or tell you where to send Bee-Bot?
CH3: Yes.
REA: And you liked that did you?
CH3: Yes.

The final subtheme was camera usage is an outlier as it was only mentioned by one child; however, it was deemed worthwhile to include it as it reflects on the child's experience of participating in a research recording. Towards the end of each focus group, the children were asked if there was anything they would like to change about the activity. One child responded that they didn't want the camera to be there. Reflecting on this response and the video recordings of the child during the activity, he did not seem uncomfortable during the recording of the sessions; however, this response during the focus group indicates he did feel uncomfortable in some way and did not want the camera there anymore while doing the activity.

REA: "Is there anything that you didn't like about it that you would like to change? So, if Teacher said next week, we're going to do Bee-Bot again, what would you like to change?
CH1: No camera."

7.5.2.2 Computational Thinking

The second theme from the focus group analysis was CT. This theme was derived from the conversations the children had around moving Bee-Bot. There are a number of examples across each of the focus groups where the children said they enjoyed watching Bee-Bot go the wrong way off the mat. It was exciting and fun for them. A number of the children indicated that pressing the buttons on Bee-Bot was their favourite thing about the activity and watching him move. While noting that Bee-Bot goes off the mat one child in the example below offers a solution to returning Bee-Bot to the mat.

REA: What did you think of it?
CH1: I pressed the buttons on the back of it.
REA: Very good anything else?
TEA: Why did you press the buttons?
CH1: Because that was my favourite part of it.
REA: And what did that do?
CH1: Then I pressed the go button, and he was going.
REA: He was going?
CH1: Where I wanted him to go. Well, sometimes he goes off the mat.
REA: And when does he go off the mat?
CH1: Mmmmmm
REA: How does that happen?
CH3: Because we press a lot of buttons too much, he goes off the mat.
REA: He loses his way, does he?
CH1: Yes
CH1: And then and then if you realise, he's going off the mat, you might need to press backwards at the end.

One child displayed the skill of debugging during the focus group identifying that they sometimes made a mistake and how that mistake impacted the route that Bee-Bot was taking. When asked about how the children completed the route with Bee-Bot and how they planned the route for him, one child mentioned that he planned it in his head. When questioned whether he used any supports, such as counting the steps with his hand, which was observed in the video recordings, he says no. The child viewed this behaviour as cheating in the game.

"REA: What about you, what did you do?
CH1: I well I just looked at the Bee-Bot mat, and I tried to count the squares in my head
REA: Yeah, ok, and then he needed to turn
CH1: I just turned him the way I counted in my head
REA: So, you are doing it all in your head. And did you ever count them with your hand?
CH1: No, because then the other people would see, and then I would be cheating, and so I was counting them in your head.
REA: And was that one of the rules that you had to count them in your head and not with your hand?
CH1: Well, I never tried it, and I don't think I will because counting in your head is better because you might not get a go, and you skip over, and then you have to say, and then you go again and then skip over you, and you don't get a turn.

7.5.2.3 Language and Attitudes

During the focus group interviews, the children were asked about whether they enjoyed the activity and if there was anything, they would like to change about it. Some of the children's outlook on the activity was mixed; they enjoyed using Bee-Bot but found it challenging at times because of the Irish language. One child commented that they didn't enjoy the activity because they found the language hard. This child made a link between the focus group conversation and the post activity questionnaire. The child clarified their negative answer in the questionnaire was because they sometimes forget their Irish words.

> *"CH3: I put a no on the thing.*
> *REA: Yeah, you put a no on it. Why did you say no then?*
> *CH3: Because I*
> *REA: Why did you think it was not fun?*
> *CH3: Because I don't know all the Irish sometimes. Sometimes I forget it. "*

Most of the children who participated in the activity had positive feedback. One child from the green group for which English was her third language and Irish is her fourth commented how much she liked Bee-Bot. While clarification was needed, she confirmed that she wouldn't change it. This child's confidence grew throughout the activity, and she can be seen enjoying coding Bee-Bot and encouraging others.

> *"CH2: I like change about it it's fun when its playing and its playing*
> *REA: Say that again you'd like to change what?*
> *CH2: I'd like to change Bee-Bot, Bee-Bot sleeping, I like Bee-Bot sleeping, and I like playing with Bee-Bot.*
> *REA: You like playing with Bee-Bot. So, is there anything you would like to change? Is there anything you would like to do differently?*
> *CH2: Shaking head (no)*
> *REA: No. You like it the way it is?*
> *CH2: Yeah"*
> *CH1: I liked doing Bee-Bot moving and saying the words we wanted him to say.*

There were mixed attitudes amongst the children with regard to choice during the play cycle. For the purposes of the research activity the children were on a rota for the Bee-Bot activity and did the activity one day a week. While some children were very happy for the teacher to decide the opposite was observed in the example below where one child felt he was missing out on the opportunity to play at another activity and one child would still choose to play with Bee-Bot.

> *REA: So, was it fun do you want to keep doing it?*
> *ALL: Yeah*
> *CH2: We do it every week. She always calls our name out cause it's on a list on our board do we get a cushion-like one of those.*
> *CH1: I don't want to*
> *REA: is that because you want to do the other activities?*
> *CH1: yeah*
> *REA: You're sad to be missing out on them*

CH1: Yeah
CH2: Is that why you're making that face?
REA: And do you want to keep going with it?
CH2: Yeah, we have a list, and when our name is called out, we go and do it, and others do the other activities.
CH1: Yeah, and it's cause it's so long.
REA: Cause it's so long that's ok
REA: And what if it was an option to do it? And you could choose which activity to do
CH1: I would choose junk art
CH2: I would choose Bee-Bot

This section presented the findings from the focus groups with the children after the six-week research activity. The main themes and subthemes from the transcript analysis were presented and included samples from the transcripts to support each theme. This section also outlined the children's perspectives on the activity and what they would like to do differently going forward. It also highlighted the children's perspectives on using Irish during the activity and their enjoyment of using Bee-Bot. While the data form the questionnaires and focus groups does not provide an insight into the use of robotics during a playful activity it does add to the rigour of this DBR mixed methods study (see section 4.7.2).

7.6 Teacher's perspective on the research intervention

Thematic analysis was carried out on the interview transcript. While the researcher looked from emerging codes from the transcript, it was apparent that there were similar themes to the children's focus groups emerging from the data. As the questions and the topic of both the children's focus groups and the teacher's interview were the same. While bearing in mind that thematic analysis should not base it themes on the questions being asked in this circumstance the response from the teacher was centred on the design of the activity and its implementation. This section will take a look at each theme according to the activity design; activity, scaffolds, data collection instruments, scaffolds, and continued integration.

7.6.1 Activity

The teacher discussed all aspects of the activity, from the unplugged activities prior to the commencement of the six-week research activity to how she would continue to implement the Bee-Bot activity after the research recordings were complete. There were a number of subthemes that arose under the main theme of activity (Appendix S), they are all interconnected to the design and implementation of the Bee-Bot activity.

As mentioned previously in section 6.1, the children took part in two weeks of unplugged activities, some SCT constructs featured during these unplugged activities. As these two weeks were not recorded, anecdotal evidence was provided by the classroom teacher during her interview.

> We used I used visual aids and then put them on the whiteboard, and then we were the human robots going ar aghaidh (forward) or cas (turn), siar and I felt it was very slow to pick up vocab.
>
> *Cycle four Teacher's interview*

Commenting on this, the teacher described how she was "*worried,"* and she thought that the children were *"not going to get this vocab at all."* Following on from this, the teacher started doing the unplugged activities in smaller groups. While she felt this was more productive and that children were using the directional language more, there was still a struggle with using the Irish directional language. She felt at this time that her expectation of the children was too high. She identified the "stronger" children as mastering the activity while others still were unsure and sat "there with vacant stares." While the children continued to participate in the unplugged activity, the teacher identified more English directional language being used rather than Irish directional language.

> *They would kind get into using their English vocab, but even with encouragement, they weren't using their Irish vocab, so I was probably had too high expectations for the Junior Infants with their Irish vocab with the unplugged activities.*
>
> *Cycle four Teacher's interview*

Reflecting on the time spent on the unplugged activities, the teacher believed it was a sufficient amount as the children's motivation had dropped. When Bee-Bot has introduced, their motivation for learning the directional language increased. The teacher commented that the children in the class are drawn to more creative activities such as junk art; they would normally engage with most activities and seem to enjoy them. However, while the unplugged activities were an option for the children to play with during the free choice play session, the teacher noticed that none of the children chose the unplugged activities. Reflecting on the design of the unplugged activities, the teacher considered that introducing it, as an Aistear (play) station might have been more effective as she would have had the opportunity to work with each small group and promote the use of Irish directional language.

As the teacher introduced the Bee-Bot activity to the class, she was very aware of ensuring that the children knew the Irish language to participate in the activity. She describes her teaching around that time as pre-teaching the Irish vocabulary prior to teaching the formal Irish lesson the topic. This meant that the children already had foundational knowledge and language of the topic they were covering. While the teacher would normally have taught directly from an Irish language programme from a publication (as per the whole school approach), she describes how she found herself now having to extend the lessons for the children. She indicates that Bee-Bot was a factor in the children's interest and motivation to learn the language due to its association with the activity.

> *There was very little teaching, like I had to extend all the Irish lessons from the programme, from the junior infant programme because they had the vocab. And then their interests, they were interested in the vocab with Bee-Bot and then, in turn, they were more interested in the formal Irish lessons as well, and the scéal (story) that happened on the board (interactive whiteboard) or the amhrán (song) or the dán (poem) or whatever we were learning all seemed to become more, become easier.*
>
> *Cycle four Teacher's interview*

The teacher covered three main topics during the research activity. As she reached the end of week four, the teacher and the researcher discussed how to extend the activity further without introducing a new topic. A decision was made to encourage the children to make up their own stories using the visuals, which were used previously. The teacher commented on the children's use of language during the final few weeks and how surprised she was to hear the children recall language they had used in week one. This was an indication of the children internalising the language they had learned a few weeks prior and been able to recall it with ease.

> *By the time we got to the last week when they were making up their own scéalta (stories), it was mad (surprising) to see them using the vocab from 6 weeks nearly seven weeks previously.*
>
> *Cycle four Teacher's interview*

As the teacher reflected on the decision to encourage the children to make up their own stories, she noted that she never had *that big of a decision to make*. This was in reference to the Irish programme that the school uses. In general, each strand of language learning from the curriculum (oral language, reading, and writing) is covered in these programmes, and schools adopted these as a whole school approach.

The teacher commented on the stage the children were at in school and how this had not been done in the school's first language (English) at that time, so to undertake such activity in their second language, Irish, was ambitious. The teacher acknowledged that the children were interested and motivated by the activity, so rather than restrict their progression and make assumptions they would not be able for such an activity, she was interested in challenging the children and extending the activity.

So, I've never had that much, and it was kind of probably brave to think that we picked scéalta for the that the Junior Infants would be making up their own stories when this is something they haven't really touched on in English. And we decided to do it in Irish. But I just thought when they were so interested, and there was such progress being made with their Irish that it was better off to challenge them and see how they would get on rather than like deciding beforehand that they didn't that they wouldn't be able for it.

Cycle four Teacher's interview

The activity provided an opportunity for the teacher to use the target language in different ways through questioning and encouraging the children to converse about the pictures on the Bee-Bot mat. This time with a small group rather than a whole class approach to a language learning activity allowed the teacher to focus on the different groups and monitor their progression.

I think in the videos, if it was like cáca, I would be like an maith leat cáca, and they would say is maith liom cáca. So, it's showing them another way they may have come across the word cáca already.

Cycle four Teacher's interview

The teacher's expectation of how the children would engage and perform during the Bee-Bot activity was challenged. Expecting some children to excel based on their performance in other activities; she noticed a difference amongst some of the children. Those who the teacher had expected to engage and have a high language output were often not the children who stood out during the activity.

Yeah, but there was definitely one or two, but that being said, those who I would have predicted weren't this strong character with Bee-Bot didn't necessarily play out as the strongest child with that given *activity. There was a few children that surprised me with how well they were able to programme Bee-Bot and use their Irish.*

Cycle four Teacher's interview

7.6.2 Data collection tools

During the interview, the teacher talked about her observations of the children's progression during the research project. Unprompted, the teacher provided her observation of some of the data collection tools. The first observation was about the pre and post activity questionnaire. The teacher at the time had asked some of the children about their responses to the post-activity questionnaire as she had observed the behaviour and engagement with the activity over six weeks. The teacher noted during the interview that some of the answers the children gave during the questionnaire did not necessarily reflect her observations during the activity. This would also align with the analysis of the video recordings.

Em, definitely another observation you might have this recorded yourself is that the children's feedback questionnaire didn't necessarily match my observation with regards to the children's learning or their enjoyment of the activity. OC2 definitely springs to mind. He loved it and was very good at it and then said the opposite then in the survey.

Cycle four Teacher's interview

One of the other data collection tools was the focus group method. The teacher brought this up during her interview. She was present for one of the focus groups, and the researcher and teacher had ongoing discussions on the day on the best approach as there was a whole school activity taking place. The children during the focus groups were quiet and often reluctant to give their opinion, or they were distracted by being in another room. The focus group where the teacher was present took place in the main classroom. While the teacher tried to encourage conversation from the children, she observed that they were reluctant to speak out while she was present, also having assumed it would have the opposite effect.

Yeah. They're just not it's not that they're not able they're just not comfortable with a focus group, are they?

7.6.3 Scaffolds

During the unplugged activities and the research activity, the teacher had physical scaffolds to use with the children. During the video recordings of the activity, the teacher can be seen distributing the a4 cards along with small picture cards to the children. They could use these to map Bee-Bot's route around the mat. From the recordings, we can observe the difficulty that was faced when trying to get the children to use the cards but also engage with Bee-Bot on the main mat. The teacher commented on these scaffolds during the interview.

They helped some of them, but some of them sometimes they were bigger challenge than they were worth. You know what I mean?

Cycle four Teacher's interview

While the teacher viewed them as more of an issue than an opportunity, she reflected on the use of them as keeping the children busy while they waited to take their turn. She also considered that she may not have spent enough time explaining what the cards were for and that perhaps that caused the difficulty with them.

Maybe it's more of a reflection that I just gave them and was like didn't spend enough time explaining them, but, in my head, I was just giving them something to keep them focused or kind of focused while they waited their turn.

Cycle four Teacher's interview

The children were observed during the research recordings playing and sorting the small pictures cards. One group of children sorts them and then converse about the characters for some time while they waited for the teacher to return. The teacher noticed how the children were engaging with the small playing cards intently and how they prompted the children to use the target language a number of times, which increased their language output.

Yeah. I just kind of left. I was like, they can look at them, even the little pictures what was good about them was every time they picked it up, they were saying the Irish word. So, they might have said it ten times in a row because they picked up the same mac tíre up ten times.

Cycle four Teacher's interview

7.6.4 Integration

The final section of the interview with the teacher reviewed the positives and negatives to the activity and the continued use of the Bee-Bot in the classroom. The teacher observed how interested the children were in learning Irish due to the introduction of

Bee-Bot. While the benefits of Bee-Bot might be observed in future across other subjects' areas such as literacy, the teacher indicated that she would consider keeping Bee-Bot for Irish to keep it a "novelty."

> *Yeah, like I know it would be beneficial, I would hate to overuse it and the novelty to wear off. But I do know how great it could for teaching phonics and spellings; CVC words, anything like it, does have endless opportunities. But that is something that I need to look into a little bit.*
>
> *Cycle four Teacher's interview*

The teacher noted the difficulty in doing the guided activity with a small group of children while other children in the class also needed her help. Prior to the research activity, the teacher would move around the room, checking in on different activities. For the research activity, the teacher stayed with the Bee-Bot station and assisted others as they came over and asked a question. This worked out for this class as the teacher noted she had established rules with the children for their activity time. She did note that this would not be an activity she would do with the children at the start of Junior Infants as these rules took time to establish with the group.

> *It is not something that I would do at the start of the year with Junior Infants. There's clear Aistear rules and boundaries, but the children in the class are aware of the rules, so it was not overly difficult like I felt it was more of a like I felt bad when a child would ask me to help them with something, and I would be working with Bee-Bot and be like I have to wait five more minutes and then I'll be able to help you. That was probably the bigger challenge was that I was like I can't be in two places at one time to help them, but discipline wise at times, the noise level got a little bit loud, but I felt that once they were reminded once that we were indoors that it was fine.*
>
> *Cycle four Teacher's interview*

The class teacher highlighted interesting points about the research activity as a whole and the impact it had on the children, and their interest in Irish. Reflecting on the children's engagement across the unplugged activities, Bee-Bot activity, engagement with the data collection tools, the scaffolds and the future of Bee-Bot in her classroom, the teacher remained positive about the impact the research activity had on both the children's perspectives of language learning and her perspective of using Bee-Bot to promote language learning.

7.7 Conclusion

This chapter presented the findings from the research activity grouped according to the research instrument. The questionnaires highlighted the broadly positive attitude the children had towards learning and using Irish during the Bee-Bot activity. However, the questionnaire did not provide an extensive amount of information on their perspectives. Similarly, the exit questionnaire provided an overview of the hugely positive response that most children had to the game and how it supported their motivation to use Irish and progress through the game. The video recordings provided a full analysis of language use, programming Bee-Bot and social interactions between the children and between the children and their teacher. The video recordings are the key sources of information for discussion. Analysis of the focus group interviews, and the game interactions illustrated a range of factors that influenced whether or not the children had a positive or negative experience towards the activity and using Irish. The interview with the classroom teacher highlighted the struggles associated with guided play with a small group of children in a whole class setting. These important findings will be critically discussed in the next chapter in order to specifically answer the research questions outlined in Section 4.1.

8 Discussion

This discussion chapter will follow a structure aligned with the three research questions of the study, and it will situate the findings within the relevant literature. The research questions are as follows:

1. What are children's attitudes towards using robotics for second language learning? (Section 8.1)
2. What evidence of language learning can be observed during a robotics-based intervention and what are the processes that support this learning? (Section 8.2)
3. What evidence of the development of computational thinking skills can be observed during a robotics intervention and what the processes that support this learning? (Section 8.3)

Section 8.1 will examine the first research question, focusing on how the findings of the current study regarding children's attitudes towards using robotics for learning Irish align with broader attitudes and motivation towards the Irish language. This section will draw connections to existing literature on this topic. In Section 8.2, the second research question will be addressed, presenting evidence of observed language learning during the robotics-based intervention, and discussing the key sociocultural constructs that facilitate this learning. The findings will be discussed within the context of relevant studies in the field. Section 8.3 will specifically delve into the participants' development in computational thinking skills, addressing the third research question. The findings related to computational thinking skills will be presented, and their implications will be discussed alongside relevant studies in the field.

8.1 Research Question 1: Children’s attitudes

This section explores the findings in relation to the children’s attitudes towards the Irish language before and after the research intervention and responds to the first research question:

What are children's attitudes towards using robotics for second language learning?

In this section, the children’s attitudes towards both learning Irish and using Bee-Bot as a tool for Irish language learning are discussed. The section also addresses the limitations of the data collection methods used with this young group of research participants. Furthermore, it explores how the introduction of a digital device like Bee-Bot can serve as a motivating factor for enhancing language learning experiences within the classroom.

8.1.1 Understanding children’s attitudes to the research intervention

This study offers a unique perspective on junior infants' attitudes to Irish language learning. While researchers and curriculum developers endeavour to include child voice in research there has been very limited research conducted on junior infants' voices in the context of the Irish language. An important part of this study was gathering children’s attitudes on different aspects of the research intervention. This included their attitude to Irish, their opportunity to use Irish and their use of technology to learn Irish. As highlighted in Section 4.6.3 gathering children’s perspectives is an important part of research with young learners. While considering a constructivist approach to learning where children find meaning in what they do, the children were asked to reflect on their own experience of the activity rather than an abstract idea (Mac Naughton, 2003). The overall response to the questionnaires given pre- intervention and post intervention, demonstrated a positive attitude towards learning Irish (Section 7.5.1). In addition to the positive attitude towards Irish most children indicated in the post-intervention questionnaire that they enjoyed using robots to learn Irish and that using robots to learn Irish was fun. The data suggests that the use of robotics had a positive impact on children’s perspectives on using Irish.

A notable discovery arising from this research intervention concerns the examination of effective methods for gathering young children's perspectives on the research intervention. To ensure meaningful inclusion of children's voices, researchers must employ age-appropriate data collection tools that enable children to express their thoughts, emotions, and experiences in ways that hold significance for them (Alderson & Morrow, 2011).

While questionnaires are considered important for incorporating children's perspectives, it was observed that the data obtained through this method can be unreliable (Piancentini et al., 2002). Notably, the presence of social desirability bias in the children's responses was evident when observed by the researcher and classroom teacher (Section 7.5.1.2). This bias could potentially influence the accuracy of the questionnaire results, serving as a limitation when using this method with young children. During the pilot studies it was found that utilising statement-based items, as opposed to direct questions, was a more suitable approach for designing questionnaires targeted at young children (section 4.7.6). However, it is important to acknowledge that the language used in these statements might inadvertently have guided the children's responses, potentially leading to a more favourable outcome in the questionnaire results (section 7.5.1). Taking this into consideration, the process of using the questionnaires is still considered an important part of the process of conducting research with young children (Section 4.6.3) as their voice is acknowledge during the research process. Given the limitations of the questionnaires and the scale of the research intervention (22 children), the focus groups emerged as a more valuable method for gathering in-depth information on the children's perspectives of the intervention. The children's participation in focus groups post-intervention provided a clearer outline of what they thought about the research intervention (Section 7.5.2). The results indicated that the children in general had a positive attitude towards the research intervention (7.5.2.3). The data showed that the children thought the purpose of the activity was in fact to move Bee-Bot and they did not link it directly to learning Irish (Section 7.5.2.1).

As the data suggests, the children had a positive attitude to the research intervention. Many of the children did not immediately connect the activity with the process of learning Irish; instead, they saw it as a natural part of the activity itself. This might indicate that the environment was relaxed and playful, allowing them to comfortably interact with one another, practice their new language, and concentrate on enjoying the activity. This positive outlook toward Irish aligns with previous research from Devitt et al., 2018 which reviewed the experiences of 9-year-olds learning Irish. Their data set was from Wave 1 of the ‘Growing Up in Ireland’ study which is the first longitudinal study of the well-being and development of children in Ireland. Wave 1 consisted of 8568 nine-year-old students from 910 schools throughout Ireland which was conducted between 2007 and 2008 (Devitt et al., 2018, pg.9). Through the analysis of this data set Devitt et al. (2018) found that the percentage of nine-year-olds who sometimes or always like Irish came to 74%. This indicated that perhaps children’s motivation for Irish has remained steady since the study from Harris and Murtagh in 1999. A review of the Primary School Curriculum (1999) by the NCCA (2008) also outlined a positive attitude amongst children to learning Irish. It was noted that children’s enjoyment of Gaeilge (Irish) particularly the use of active learning methods (drama, role play, songs, rhymes and poems, and games) and their use of oral language as part of the communicative approach to learning Gaeilge were identified by teachers as key success to children learning Irish (NCCA, 2008, pg.16). The emphasis was placed on using the language in practical scenarios and treating it as a living language.

While prior studies in this field have primarily concentrated on older children's viewpoints regarding Irish language acquisition, such as the work by Devitt et al. (2018) with nine-year-old children and Harris and Murtagh (1999) with sixth class students (typically aged 11-12), this study makes a significant contribution by shedding light on the language learning attitudes of the youngest students in primary schools. Although the sample size for the research intervention is small, it offers a unique perspective on the attitudes of children attending English medium primary schools towards learning Irish, which is a relatively uncommon focus in existing research (Harris et al., 2006).

8.1.2 Bee-Bot, a motivation to participate

The results of this research intervention revealed interesting findings regarding children's attitudes towards using Bee-Bot for second language learning. Overall, both the questionnaire and the focus group indicated that the children enjoyed using Bee-Bot (Figure 30 and Section 7.5). The children viewed the activity with Bee-Bot as a game conducted in Irish (Section 7.5.2.1), which served as a motivating factor for most children. As discussed in Section 2.3.1, the Communicative Language Teaching (CLT) approach promotes a more practical and enjoyable learning environment for language learning. By incorporating language use in a purposeful manner, such as through a game, it can have a positive impact on learners' attitudes which aligns with the findings from the NCCA (2008). The children emphasised that "Bee-Bot only speaks Irish," making Irish the medium of communication for the game. While this was the prevailing viewpoint, one participant expressed a contrasting opinion. This child felt that the language posed a barrier to their participation in the activity. They were hesitant to engage when they were unsure of the directional or target language. While this perspective differs from most children in this study, it aligns with the views expressed by the children in the study conducted by Harris et al. (2006).

The classroom teacher's emphasis on the influence of Bee-Bot on language learning (Section 7.6), as highlighted during the intervention, mirrors the findings outlined in Section 7.3. The integration of Bee-Bot into the learning process had an interesting impact on the children's engagement in their daily Irish language lessons (Section 7.6.4). The teacher observed a notable increase in the children’s motivation to engage with their language lesson so they could use that language later with Bee-Bot. The introduction of Bee-Bot brought a sense of enthusiasm to the experience of learning Irish in the classroom, especially within the framework of a playful and interactive activity.

It is important to consider that the children's favourable attitudes toward the Bee-Bot activity may have been influenced by the novelty effect, a phenomenon described by

Clark & Sugrue (1988) as the improvement in human performance due to exposure to novel stimuli. This effect could pose a threat to external validity, as noted by Gravetter and Forzano (2018), leading to differences in how people react in a research study compared to a real-world setting. Research by Henderson and Yeow (2012) underscores the existence of an initial novelty effect associated with the introduction of new technological tools in educational settings. However, they caution that if educators adhere to unvaried teaching methodologies, employ identical applications, and consistently utilise the device in the same manner for prolonged periods, the initial allure of the technology can diminish, along with its benefits. The concept of novelty was explored by Henderson and Yeow (2012) in their study that examined the incorporation of iPads in classrooms. The study aimed to ascertain whether this novelty effect influenced the extent of sustained engagement with the device. During their investigation, Henderson and Yeow (2012) conducted semi-structured interviews with educators from a primary school in New Zealand, several months after the introduction of iPads into the learning environment. Although the teachers initially identified a sense of novelty associated with the iPads, this waned within a few days, and the iPads gradually transformed into established "learning tools" within the classroom proving they could have a long-lasting positive impact on learning.

This research intervention with Bee-Bot lasted six weeks, making it challenging to assess if Bee-Bot's novelty factor would diminish and if it could become a long-term classroom tool. As mentioned in Section 4.3 & 7.6.4, Bee-Bot's versatility allows for its environment (the floor mat) to change depending on the theme or focus of learning. This could prove particularly beneficial for sustaining Bee-Bot as a long-term learning tool for language development and cross-curricular integration. Adding Bee-Bot to the play session whereby children can enjoy the activity once a week would also add to it sustainability as a classroom activity. Fundamentally, Bee-Bot's flexibility and its ability to align with various educational contexts could make it a valuable and enduring classroom tool, even beyond its initial novelty phase.

8.1.3 Summary

This section explored children's attitudes towards using robotics for second language learning. The findings indicate a positive outlook on learning Irish among the participants however limitations regarding gathering reliable data from young children was addressed. Questionnaires with this young cohort were deemed potentially unreliable because they may be susceptible to social desirability bias and positive attitudes observed during the intervention may have been influenced by the novelty effect, though Bee-Bot's adaptability and versatility in various learning contexts suggest its potential for long-term engagement. The study underscores the motivating impact of Bee-Bot in Irish language lessons and its potential to sustain enthusiasm in language learning through an interactive and playful activity, emphasising the importance of engaging pedagogical approaches in second language education.

8.2 Research Question 2: Language learning and supporting processes

This section explores the findings in relation to second language learning during the intervention and the supporting processes and responds to the second research question:

What evidence of language learning can be observed during a robotics-based intervention and what are the processes that support this learning?

This study provided a unique perspective of a real world junior infant language learning classroom activity. This section discusses the evidence of language development among the 4- and 5-year-olds and the processes that underpinned this learning. In line with the literature, the children's language development is primarily in terms of vocabulary (Section 7.3.1), in particular noun phrases that they use with English to communicate with each other and engage in the activity. This section will explore how translanguaging can be used to support second language learning during classroom activities. The role of the classroom teacher and their impact on the children's learning and the learning environment is explored in Section 8.2.3.

8.2.1 Language development

This research intervention investigated second language learning (Irish) in an English Medium junior infant classroom. There is a notable lack of research in this area with this age group. This research intervention focused on social, target and functional language use through Irish in the infant classroom. There was no expectation that the children would become fluent users of Irish or that they would have complete conversations in the language. As the children had been in school for four months prior to the research intervention and received 20-25mins of Irish language lessons a day, it was expected they would increase their language use and practical context in the classroom. The data from the in-depth analysis of the children's use of their second language was noted as increasing from day 1 of the intervention to day 5 (Table 17), in particular their use of social and target language. On average the children used 6 Irish words during the activity on day 1 and 11.4 Irish words on day 5 (Table 17). The research intervention sought to analyse a specific set of words which were being taught through storytelling during the

Irish language lesson and if they would continue to be used during the intervention (Appendix J). While quantitatively, the volume of Irish in use may appear small, this should be considered in the context of the English Medium junior infant classroom where children's use of Irish in a communicative context is minimal. It is essential to note that when examining older class groups, where there is a heightened expectation for language use, the findings consistently indicate a deficiency in opportunities for children to use the Irish language functionally (DES, 2007; Harris et al., 2006). This study offers that context and within a short time frame sees children increasing their use of their available resources and using Irish in practical scenarios (NCCA, 2008).

In English Medium schools in Ireland, the teaching of nouns during second language learning lessons is commonplace in the junior infant classroom as children begin to name and identify objects in the classroom and in picture books. This approach has been criticised by the DES (2007). The Chief Inspector's Report, *Irish in the Primary School* (2007) found that often there was sole focus on teaching nouns without offering children a context or opportunity to practise them. The report highlights that in some classes' children knew a range of nouns but did not know sufficient verbs and prepositions to communicate. Contrary to the DES (2007) report the children during this research intervention had an opportunity to practise their new language in a playful environment. Their second language use at the start of the research intervention was mainly identifying what was on the picture cards as they told a story with Bee-Bot. Towards the latter end of the intervention children used their Irish language mixed with English to build coherent sentences so they could engage with each other and the activity (Appendix N).

8.2.2 Storytelling

This section will explore the children's language learning through the use of storytelling as an effective method for second language learning in the early years' classroom. Story in the research intervention provided a focus and scaffold for the children as they developed their second language. As outlined by Ó Duibhir and Cummins (2012, pp. 37-58) children acquire essential oral vocabulary and phrases by imitating language patterns presented in stories, songs, play activities, and everyday routines. Ioannou-Georgiou and Verdugo (2011) further highlight that stories serve as a linguistic tool that incorporates grammar, vocabulary, and ready-made speech in a meaningful and structured context. This research context supports comprehension of the narrative world and the subject matter associated with the story (Glazer & Burke, 1994; Jennings, 1991; Koisawalia, 2005). The development of children's language skills throughout the research intervention indicates that story played an important role in facilitating language learning and motivating young learners to practice their new language (Section 7.3).

Ellis (2005) outlines that “successful instructed language learning also requires opportunities for output”. The research intervention offered the children and opportunity to use the language they had learned during the language lesson. Quite often language learning is confined to the language lesson and never moves beyond this within the timetable (Menken, 2023). The DES (2007) noted that teachers did not give children enough time to create and practise their new language in school. When opportunities were provided to use their second language the activities were not connected with a specific language input and learning outcomes were limited (DES, 2007). A significant finding from this is the opportunity to create a space within the classroom for junior infants to practise their second language. The initial four sessions of the research intervention followed a structured approach where story provided a scaffold for the children to practise their L2, moreover during the final session the children created their own stories as a group. As highlighted by the children in Section 7.5.2.1, the final session was one of their favourite sessions and it also supported their autonomy to choose what story to create with their peers (Section 2.2.5). The data suggests that the autonomy to create their own stories on day 5 did not have an impact on their L2 output. This would indicate that the story scaffolds (CH4, Appendix F) that were provided were still supportive to the children as they created their own stories. In line with Owens (2012, p.322) from the age of 4 children begin to include elements of narrative within their story telling but sometimes lack the skills to construct a clear narrative however from the age of 5-7 clear narrative plots begin to emerge (Owens, 2012). Clear narrative plots were identified amongst the groups on day 5 while also including elements from the stories covered during their Irish language lessons (Section 7.3.2). Drawing on the language they had learned over the previous four weeks they created their own stories using the picture cards for the floor mat (Section 7.3.2).

Mhic Mhathúna (2008) emphasises the significance of storytelling as an integral aspect of childhood, further noting its pivotal role for language learning in the early childhood curriculum. Through the observation of story time and interviews with staff in a Naíonra (Irish Medium Pre-school) Mhic Mhathúna found that storytelling substantially aids in the acquisition of a second language (Mhic Mhathúna, 2008). In line with this research intervention, Mhic Mhathúna (2008) study indicated that as children immerse themselves in stories told in a second language, they progressively sharpen their narrative skills. Initially reliant on visual aids like picture cards and verbal cues from teachers, they gradually cultivate the ability to articulate short narratives. Through the use of story in the language lesson and then the opportunity to retell the story during the research intervention the children built up a bank of words and phrases which even included one child saying *Fadó fadó* (A long time ago) (Section 7.3.2). Mhic Mhathúna (2008) emphasises the importance of telling and retelling stories at this early age as an important part of the language learning process. During the final session of the research intervention the children created their own stories. As highlighted by the children in Section 7.5.2.1 this was one of their favourite sessions. Pulling on the language they had learned over the previous five weeks they created their own story for Bee-Bot to follow.

Research indicates that storytelling is not only an effective method to promote second language learning it can also promote CT skill development. A study conducted by Tengler et al., (2022) outlines the use of fairy tales and familiar stories to support children's CT skill development. The children planned a story map based on the stories told in class for their robot (Ozobot) and programmed the robot to follow the route. The children planned the route with each other and then retold the story through the movement of the robot (Tengler et al., 2022). The research intervention demonstrates how the use of the robot as a mediator to retell stories not only supported the children's CT skills development (Section 7.4) but also the how the use of story can support second language learning in the classroom. Through the integration of story and robotics the children

8.2.3 CLIL environment

The literature review (Section 2.3.3.1) highlighted that language instruction goes beyond merely teaching a language; it also involves teaching children (Ó Duibhir & Cummins, 2012). The research intervention outlined in this study presents an opportunity for implementing Content and Language Integrated Learning (CLIL) in early year's classrooms. CLIL, an educational approach in which the target language is utilised as the medium of instruction for both content and language acquisition (Harris and Ó Duibhir, 2011). It has secured its position in Europe over the past 25 years a way to improve linguistic competence without crowding the curriculum and to make language learning interesting and impactful (Mair, 2020). The study's findings indicate that children actively engaged in the programming tasks using Bee-Bot while also using the Irish language during the playful activity (as discussed in sections 7.3.1 and 7.4.4). The findings indicate that the children viewed the activity as stimulating and were encouraged to use their new language.

Typically, a CLIL lesson places its primary emphasis on content, using the target language as the medium through which children interact with the subject matter. This approach facilitates the achievement of both content and language objectives within the same lesson. CLIL aligns with a communicative approach (Section 2.3.3) to language teaching, as it provides an authentic context for second language (L2) acquisition and usage (Harris and Ó Duibhir, 2011). Creating genuine situations for children has proven to be a difficulty when implementing a communicative teaching approach. The idea of context is crucial for children to understand the content in their lessons. Because the content is intertwined with a specific context, children rely on this contextual information and their prior knowledge to understand the lesson. Furthermore, being able to think in another language can enhance the process of learning the subject matter in a favourable way.

Within research, there are a limited number of CLIL studies involving children aged between3-6 years old, as indicated by Mair (2020). According to Ruiz de Zarobe (2013, p. 231) preschool CLIL projects may be under-documented in European data because more than at other levels, they are the result of “individual initiatives undertaken by school communities, teachers and parents” (Mair, 2020). As outlined in Section 2.3.3.1, the few CLIL preschool programs that are documented involved low exposure approaches (Bentley, 2015). With this young cohort, the use of a wide-ranging theme or “language showers” approach provides a practical and theoretically sound platform for the introduction of CLIL (Marsh, 2012, pg. 205). The documented use of “CLIL showers” in the classroom is similar to the context of this research intervention whereby children are provided with exposure to the L2 during short daily bursts. Their first exposure is during the daily language lesson and the second was during the research intervention.

Aligning with the previous section on storytelling (Section 8.2.2) Ioannou Georgiou, (2015) advocates that storytelling is an appropriate and effective context for CLIL in the early year's classroom. Through her pilot study of compulsory English Language Learning of 550 children, aged between 4 and 5years old across 10 pre-primary schools, Ioannou Georgiou advocates for “CLIL showers” involving regular or daily short sessions in the CLIL language, using games, songs, and stories. Further recommendations from her study (Ioannou-Georgiou and Pavlou 2011) indicate that there are several points teachers should consider when selecting a story for CLIL; a clear storyline; plenty of repetition; opportunities for participation; helpful illustrations; and appropriate linguistic level (Ioannou-Georgiou, 2011). The data from this research intervention aligns with each of these recommendations which demonstrates the opportunity to establish a CLIL environment in the early years in Ireland using robotics. The research design (Section 4.6) used three clear familiar storylines where the children could draw on their existing knowledge to support them and they were not dependent on consistent linguistic input from their teacher throughout the intervention. The use of repetition within the fairy tale story i.e., Na Trí Mhuicín (The three little pigs) provided the children with more opportunities for hearing language and see the language in action. The opportunity to participate in storytelling was created using Bee-Bot, the floor mat and clear and colourful illustrations. The children had the opportunity to discuss the pictures in the story and repeat key phrase that the characters would say. The stories that were chosen were at the children's language level and was supported by telling and retelling of the story by their teacher.

For teachers, the use of stories as a tool for CLIL provides opportunities for integrating Irish across the curriculum in an active and meaningful way. An important consideration in this regard is the teacher's confidence and proficiency in the language. Teachers may begin their planning by choosing a subject in which they are comfortable communicating through Irish, that lends itself to CLIL and that offers opportunities for discussion and active engagement by children in groups (PLC, 2019, p. 41). This study highlights that the use and accuracy of the L2 by the teacher is an important aspect to the fulfilment of the CLIL lesson. The teacher spoke less than 50% Irish over the course of each play session. While this may be considered as having a negative impact on the children's language learning it does in fact align with the "soft CLIL" approach as defined by Bentley (2015). The aim of the "soft CLIL" approach with young learners is not language proficiency but to increase and promote language output, enhance language awareness and establish a foundation for further language development in the follow school years (Marsh, 2012). The quality of language used by the teacher is also an important element so that high quality L2 is demonstrated to the children consistently. While quality and consistency posed a potential issue for the implementation of the research activity there was still evidence of language development amongst each of the groups. The observed positivity and language development among the children provide substantial evidence in favour of the notion that this approach holds great promise as an initial step. It underscores the critical importance of establishing a positive and practical orientation toward the language in the initial stages of language acquisition. The study demonstrates how a CLIL environment can effectively support children's second language learning during a playful robotics activity in the early years.

The playful context of the research intervention provided an opportunity to integrate second language learning and robotics. As outlined in Section 2.3.3.2, play contributes to child development in many ways including linguistic development. The PLC (2019) outlines that playful approaches generally happen in three different ways: play that is completely directed by the child/children; playful activities that are planned and led by the teacher; and times when the teacher and the children share play activity. These are all opportunities for children to experience and use all aspects of their developing literacy in an integrated way. Children become more autonomous and motivated language learners through opportunities for enjoyable interaction with others (Ó Duibhir and Cummins, 2012, pp. 37-58).
The teacher set up the research activity and offered support at the beginning and end of each session. The teacher was observed during the research intervention establishing the activity and scaffolding for a short period of time before stepping away so the children could continue independently. This independent time engaging with Bee-Bot without the teacher was an important aspect of the research intervention.

An interesting finding was the children's commentary on their final session (Section 7.5.2), where they exhibited a high level of engagement when they could plan the entire activity together as a group. This finding reflects the significance of autonomy in the playful learning environment, as discussed in section 2.2.5. The teacher's role in establishing autonomy was evident through set up of the activity - demonstrating collaboration, turn-taking, and praise, which contributed to fostering a positive learning environment for the children. The children's heightened enthusiasm during the final session, where they had complete control over the playful activity, demonstrated the positive impact and importance of autonomy during play. The incorporation of both teacher guidance and learner autonomy strikes a balance between structured instruction and student-centred learning, as suggested by Dam (2011). This pedagogical approach empowered the learners to assume greater ownership of their learning journey, while benefiting from the teacher's expertise and support, as emphasised by Benson (2001, 2007). Such a balanced approach can lead to more meaningful and sustainable learning experiences, fostering skills and metacognitive strategies essential for autonomous learning (Dam, 2011; Little, 1991).

8.2.4 Supportive constructs within SCT

8.2.4.1 The impact of the More Knowledgeable Other

The findings of this research intervention (Section 7.2.4) shed light on the significance of children as More Knowledgeable Others (MKOs) within the context of language learning, activity participation, and social development. Initially, it was expected that the role of the MKO would be fulfilled by the classroom teacher, drawing on Vygotsky's theory of social development and the zone of proximal development (ZPD) (Vygotsky, 1978). However, a surprising and significant discovery emerged during the study: within each group, one or two children took on the role of the MKO, demonstrating their understanding of tasks and language proficiency, and subsequently supporting their peers in the group.

Creating an environment where collaboration towards a shared objective is fostered necessitates the presence of certain elements. One such element is the establishment of a sense of connection among individuals, emphasising their collective pursuit of a common goal. Notably, during the activity, while children engaged in play with one another and manoeuvred Bee-Bot, specific individuals were observed assuming the role of supporters, actively aiding their peers in task completion (Section 7.2.4). In the data analysis, these children's actions were categorised as those of More Knowledgeable Others (MKOs). The supportive behaviour exhibited by these children yielded valuable insights into the role of MKOs within groups of young children. Their actions facilitated enhanced connections among the groups and promoted intrinsic motivation among those facing challenges. This was particularly evident when children's language output was supported or when tasks were tailored to accommodate different group members' abilities (Appendix M). The MKOs acted similarly to the classroom teacher in terms of providing support.

Through the process of mediation, the children supported each other through a mixture of English and Irish as they took part in the activity with Bee-Bot (Section 7.2.1 & 7.3.1). This mixture of language happened in smooth transition as the children added Irish words to their sentences. In general, the children who spoke the most were identified as the MKO’s of the group (Section 7.3.3, CH1 and CH3). There is very little in-depth research in the area of young children acting as MKO’s in an EAL or SLL setting and even less outside this context. The findings from a case study observing peer interactions of pre-schoolers learning EAL conducted by Farndale, Harris, & de Courcy (2016), highlighted the contributions of MKO peer partnerships where some children acted as English language role models. Over a six-month period, the researchers observed four preschool-aged children that they were new to English and in the initial stages of speaking EAL (Farndale, Harris, & de Courcy, 2016). The behaviour of the children on the receiving end of the MKO’s support was recognised through imitation, exposure to language, encouraged pushed output (Swain 2005) or purposeful contextual communication. Similarly, during this research intervention, the relationship between the MKO and other group members mirrored the interaction between the classroom teacher and the children during her supportive role. The MKOs in each group exhibited behaviours such as monitoring the group's progress, ensuring adherence to turn-taking rules, and adjusting their scaffolding techniques according to individual abilities (Section 7.3.3). Notably, they utilised functional language effectively, offering directions and suggestions to others in Irish, a language that was consistently present through Bee-Bot's outputs (Section 4.3).

An intriguing finding emerged when the MKOs' roles were not fixed throughout the intervention. When the identified MKO in the Green Group CH1 (Section 7.3.3) continued to participate in the research intervention their language output decreased from day 3 to day 5 whereas the other identified MKO of the group CH3, their language output increased. This highlights the dynamic nature of the MKO role, which can shift between different children during various stages of the activity. The child's transition from the MKO to the role of the group participant in situations where perhaps tasks proved too difficult, or they were unmotivated to actively participate was evident. This movement of the role of the MKO from one individual to another and to an artifact aligns with the concept of multi-directional ZPD proposed by Abtahi, Graven, and Lerman (2017). The Bee-Bot itself acted as a consistent MKO, aiding the children with its audio prompts (consistent language mediation), error indication (arriving at the wrong picture card and mediating the story (Section 4.3). According to Ryan and Deci (2020), effective facilitation of learning environments necessitates essential supportive elements, including autonomy support and structure. Autonomy support, in this context, refers to interpersonal behaviours displayed by the classroom teacher and other children (MKOs) during an activity, aimed at recognising, nurturing, and developing children' intrinsic motivational resources (Deci & Ryan, 1985; Reeve, Deci, & Ryan, 2004; Núñez & León, 2015). Therefore, autonomy support entails creating an atmosphere where children are not coerced into conforming to specific behaviours, but rather encouraged to express their authentic selves and take risks (Ryan & Deci, 2004).

The children's embodiment of the MKO role was not limited to language mediation alone; they also utilised other mediating tools available during the activity, such as Bee-Bot and the floor mat (Section 7.3.2 and Section 7.3.3). The observation of dynamic scaffolding early in the research intervention, with the teacher adapting her support for different group members, might have influenced the MKOs in how they supported their peers.

These young MKOs even employed phrases of encouragement (maith thú – well done), showcasing characteristics such as patience, encouragement, and positive feedback.

During this research activity, the MKOs were observed forging connections and providing support to others. Their actions fostered a sense of community within the group and ensured that all children felt included and capable of accomplishing the designated tasks, thereby enhancing their well-being, and fostering a positive attitude towards the activity. Bee-Bot was also perceived as a supportive group member. Beyond serving as a scaffold for learning Irish, the tool acted as an additional MKO (section 2.3.1), reminding children of their target language, and cultivating a supportive and enjoyable environment.

8.2.4.2 Scaffolds

This section discusses the scaffolds that were provided to the children and how effective they were in supporting the child's language development. The crucial aspect of the research intervention was creating an environment or a ZPD, where the children were challenged and could progress. This meant providing dynamic scaffolding for the children.

According to Wood et al. (1976), scaffolding can be defined as a "process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts". Scaffolding is used in different learning contexts at different ages and goes beyond adult or MKO support to include support from physical supports such as computer-assisted tools. Swain and Lapkin (2013, p. 119) defined scaffolding from the cognitive perspective for language learners, specifically, immersion education. They state, "a more expert learner or a teacher helps another person to go beyond what he/she can do alone in, for example, linguistic expression, conceptual understanding, or performing an action." The variety of scaffolds (Bee-Bot, floor mat, picture cards etc.) were effective during this research intervention (Section 7.2.5 & 7.6.3, Figure 15 & 16). As per DBR the scaffolding provided was adjusted regularly according to the children's movement through their ZPD.

The physical environment established for this Irish language focused activity was part of the process that supported the children's language learning. The floor mat maintained was always focused on the theme and story, the picture cards promoted the children's storytelling and creativity, and the Bee-Bot was a constant contributor and mediator of the Irish language. Swain and Lapkin outline the importance of creating a classroom environment whereby the children have to produce their own language (Swain and

Lapkin, 1995). Principle 7 of Ellis' (2005) ten principles of instructed language and teaching outlines that children need to be given space and the opportunity for language output. By creating this space, the children become aware of the linguistic problems they encounter and must self-correct which in turn facilitates their language development. The activity environment encouraged the children to use the Irish language with a specific focus on language from their Irish lesson i.e., familiar words and phrases. The activity was designed (section 4) so that the children would not only be encouraged but also pushed beyond their current language level. Swain claims that it is when learners try communicate meaning and encounter the limits of their language that they recognise what they need to learn (Swain, 1985).

The research findings highlighted that the floor mat was one of the more important physical scaffolds provided to the children throughout the research intervention (Section 7.2.2. It was a constant mediator of language and regulator of the activity. The mat changed according to the target language set out in the children's language lessons. It was beneficial to the teacher's practice as she used it as a supporting scaffold to review the language with the children, the children used the pictures on the mat when directing others. The floor mat provided a story path for Bee-Bot to follow as the children completed the instructional tasks. The pictures on the mat acted as a prompt and guided the children through the story. Aligning with dynamic scaffolding approach and the DBR methodology, the children were challenged to tell their own story with a variety of familiar pictures on the final day. Interestingly as the floor mat was an important scaffold throughout the research intervention it played a crucial role on the final day in supporting the children. The familiar pictures represented familiar characters and phrases from stories which they adapted to suit their own story.

Collaborative storytelling was a challenge for the children and Bee-Bot was one of the central physical scaffolds of this research intervention. As set out on Section 1.1 the aims of this research were to investigate how Bee-Bot could support second language learning. The results indicate the positive impact the programmable floor robot had on the children's second language learning. While effective in providing a focus for storytelling during the activity, it also supported the use of functional language early on.

8.2.5 Teacher's role in facilitating learning through play

In the context of this study, the children demonstrated development of language use within the context of an intervention where Irish was modelled but mixed with English. The recent debates about translanguaging as a pedagogical tool are often situated in contexts which are radically different to the minority heritage language context of Ireland. In the literature on translanguaging, the emphasis is on allowing learners and their teachers to move fluently within their language repertoires as the context demands. However, in the Irish context, where English is hugely dominant and most learners only have contact with the minority language through their teacher, the evidence base for translanguaging requires greater consideration. This study highlights the need to interrogate translanguaging approaches in contexts such as Ireland where the language is under threat.

The study's findings indicate that the teacher utilised the Irish language for less than half of the time when introducing the research intervention and providing support to the children. This was not the ideal scenario as it was intended the activity be conducted completely through Irish. During the research intervention, the teacher frequently employed a mixture of English and Irish, and although there were instances of errors in Irish language usage, Irish was still incorporated during the activities. This less than expected use of Irish by the teacher corresponds with prior research in this field (DES, 2007; Harris et al., 2006; NCCA, 2008).
Despite occasional grammatical inaccuracies in the teacher's Irish speech, the children demonstrated success in increasing their usage of the Irish language throughout the intervention. It is essential to take into account the context of this research intervention, which took place in an English Medium School, where the classroom teacher dedicated approximately 20-25 minutes per day to teaching Irish to junior infants, with informal Irish occasionally integrated throughout the day. While the research intervention took place in Irish there were four other activities running simultaneously through English. Although the initial plan was to conduct the research exclusively in Irish, the actual implementation resulted in a mixture of Irish and English usage.

The findings from the intervention outline the positive impact that emphasising nouns and simple outputs can have on young learners L2 (DES, 2007) (Appendix J). The language lesson’s emphasis on short sentences and isolated nouns aligns with PLC (2019) and served as an accessible way for young children to identify objects, directions, and emotions, thereby laying a strong foundation for their language development in Irish. This echoes Cummins' and Genesee's research, highlighting the importance of providing young learners with a solid language base to facilitate their language learning journey (Cummins, 2000; Genesee, 1987).While the emphasis by the teacher on nouns and simple outputs proves advantageous for young learners, the DES report *Irish in the classroom,* highlights the need for teachers to develop more comprehensive strategies for teaching Irish (DES, 2007). This also highlights the importance of addressing challenges faced by educators when creating an immersive learning environment for primary school.

Ó Laoire (2007) study on student teacher attitudes to Irish found that the majority of student teachers showed a positive attitude towards Irish, which is in line with previous research (Committee on Irish Language Attitudes Research (CILAR)), 1975; P Ó Riagáin & Ó Gliasáin,1984, 1994). However, Ó Laoire suggests that this attitude is primarily a functional one relating to doing well in exams or getting a job. He claims that the positive attitude of these student teachers is a “passive stance rather than a proactive attitude”, as there is no evidence that they are taking active steps to promote Irish speaking (p.181).

According to the DES (2007) report, most teachers (68%) used Irish as the language of instruction throughout the lessons observed. In those classes where this good practice was taking place the teachers used appropriate resources and visual materials during the pre-communicative phase to explain the language and to help the pupils to understand the new language. When teachers continuously spoke in Irish pupils had a valuable opportunity to learn a living language spoken naturally, and this assisted them in understanding the language. The teachers’ language use provided pupils with an exemplar for modelling language. While the research intervention intended to immerse the children in Irish for the activity the reality was that the classroom teacher spoke Irish less than half the time (Figure 25), and less than 40% of the time for some groups. Within the context of the research intervention whereby one group of children were encouraged to use Irish during the play session the rest of the class were using English. The context of the in the junior infant classroom during the play session was a limitation for the teacher whereby they had to manage the rest of the classroom while also setting up and supporting the research intervention through Irish.

This mixture of English and Irish language use by the teacher prompts the consideration of a translanguaging approach in the classroom. Translanguaging, when applied to minority language instruction, presents both challenges and opportunities for learners, as discussed by Cenoz and Gorter (2017) and Duarte (2019) (Section2.3.3.3). It involves a delicate balance of using the majority language while also supporting and preserving the endangered language, such as Basque or Irish, without isolating it from other languages. Some critics argue that promoting language mixing through translanguaging conflicts with the idea of strict immersion in language teaching. However, this study recognises the realities of early years' classrooms and the pressures they face. In response to these challenges, adopting translanguaging as an adaptive pedagogical strategy becomes necessary, as suggested by Palmer (2018). By embracing language mixing and translanguaging, educators can create a more inclusive and supportive learning environment for young students, effectively harnessing their linguistic diversity. In the case of endangered languages like Irish, promoting translanguaging in the learning context is crucial for its preservation and continuity. The debate over the appropriate use of the first language (L1) in language learning contexts, whether it's immersion, Content and Language Integrated Learning (CLIL), or traditional language classrooms, is ongoing and ever evolving. In the context of English as an Additional Language (EAL), there is a strong emphasis on valuing and using non-majority L1s as a valuable resource. However, in a minority language learning context, striking the right balance is more challenging due to the need for input in the minority language while ensuring optimal access to the language. Cook (2001) outlines the usefulness of the L1 in the L2 classroom while acknowledging the long-standing debate about separating the L1 and L2. Children must comprehend the activities they are engaged in, and using the L1 to establish a common understanding can ultimately enhance L2 activities. Additionally, Cook (2001) notes that young language learners may lose focus, leading to behavioural issues, and using the L1 can help teachers regain control and keep the class on track.

In recent years, there has been a shift in understanding of the role of the L1 in the L2 classroom, moving from strict immersion to the concept of translanguaging. This transition is particularly pronounced in the context of English Medium schools, where maintaining a purely immersive Irish environment is challenging due to the dominance of English. Consequently, teachers may resort to code-switching and using children's L1 to manage behaviour or quickly address confusion during language-based activities. This aligns with Cook's (2001) findings, emphasising the practicality of using the L1 for efficient classroom management and comprehension. Cook (2001) also highlights the importance of children understanding activity instructions before transitioning into the L2 for completion.

This research intervention demonstrates the potential benefits of incorporating translanguaging into language learning environments. Carefully integrating children's L1 alongside the target language can positively contribute to their overall learning experience and promote bilingual proficiency development. These findings are consistent with the research of García and Sylvan (2011), Baker, and Wright (2017), and Canagarajah (2011), emphasising the significance of aligning language teaching strategies with learners' linguistic and educational needs. According to Nikula and Moore (2019), translanguaging suggests that bilingual individuals possess a single linguistic repertoire from which they strategically select elements to ensure effective communication. This concept may have relevant when using CLIL in the primary school context as it could potentially enhance learning and cognitive processing of concepts (Mair, 2020). Coyle et al. (2010, p. 37) note, it's crucial for teachers and learners to purposefully capture, recycle, and foster the development of children's emerging language abilities. This study sheds light on the complexities and potential advantages of embracing translanguaging in language learning activities.

8.2.6 Research Question 2 summary response

The study's language development findings demonstrate an increase in Irish language output over the six-week intervention period, facilitated by an engaging storytelling activity. Of particular interest, is the development of social and target language, as detailed in Section 7.4.1.These findings underscore the importance of not only fostering language skills in young learners but also cultivating a positive outlook on the language's significance and relevance. The study's unique approach lies in its ability to examine language learning in a real-world context, capturing how participants used the language they were taught. This context-specific evaluation offers valuable insights into the practical effectiveness of CLIL and translanguaging and sheds light on how language skills are acquired in real-life scenarios. The role of the More Knowledgeable Other (MKO) was explored in Section 8.2.4.1, where both teachers and children assumed this role dynamically. Additionally, the study highlighted the supportive role of environmental artifacts, particularly the Bee-Bot, in aiding children's language development.

This analysis provides a detailed perspective on language development in early year’s education, a perspective often lacking in the existing literature. The challenges faced in Irish classrooms within English Medium schools are multifaceted and necessitate thorough examination. Addressing these challenges is essential for the preservation and revitalisation of the Irish language, especially given its minority status and vulnerability when compared to English, the dominant language

8.3 Research Question 3: Computational thinking skills development

This section explores the findings in relation to computational thinking skills and the processes that support this and responds to the third research question:

What evidence of the development of computational thinking skills can be observed during a robotics intervention and what the processes that support this learning?

This study provided an in-depth perspective of a real world junior infant play session that integrated robotics and second language learning. This section discusses the evidence of CT skills learning gains among the 4- and 5-year-olds and the processes that supported this development. Aligning with literature in this area, this section explores the integration of CT skills and storytelling and the impact it can have on CT skill development. This section will also explore the processes which support CT skills development during the research intervention.

8.3.1 Learning gains

The research offers valuable findings regarding the advantages of a playful storytelling activity using robotics in the early primary classroom. Through the integration of Bee-Bot, a floor programmable robot, this intervention enabled children to engage in storytelling, promoting the development of computational thinking skills and facilitating second language learning. Stork (2020) outlines that the use of robotics in educational settings has become more prevalent in recent years. The use of robotics not only enhances the u interest and curiosity but it they also promote additional skills such as initiative, responsibility, creativity and teamwork (Stork, 2020).

The findings from this intervention (Section 7.4) align with previous research in the field of educational robotics and computational thinking, supporting the potential benefits of incorporating robotics activities into primary education (Angeli et al., 2016). The research intervention adopted the computational thinking curriculum framework for children aged 6-8 developed by Angeli et al. (2016) (Table 2). The findings in Section 7.4.4 outlined that the children completed a variety of tasks during the research intervention varying in difficulty from easy, medium and hard (Figure 17 & Table 26). On average the children took less attempts to complete harder tasks by the end of the intervention. This indicated an improvement in their algorithmic thinking. The notable improvement in algorithmic thinking skills observed over the 6-week intervention is consistent with the study conducted by Sullivan and Bers (2015), emphasising the positive impact of robotics interventions on students' cognitive development and problem-solving abilities. Sullivan and Bers (2015) conducted an 8-week study to assess children’s learning outcomes from a robotics curriculum. The study was conducted with children from pre-kindergarten through second grade (N=60) where each grade level was assigned ‘Solve-it’ tasks. Through this robotics-based curriculum the children explored the theme ‘‘Me and My

Community'' through storytelling. The study outlined that across kindergarten, first and second grade the children could complete their assigned tasks but the children in second grade had the highest scores. Interestingly the pre-kindergarten group struggled when tasked with completing a sequence of more than five steps correctly.

During this intervention with Bee-Bot the children's ability to efficiently complete tasks of increasing complexity with fewer steps highlights their successful integration of computational thinking skills during a playful classroom activity, reinforcing the effectiveness of such pedagogical approaches (Bers, 2020). As the children's algorithmic skills improved the data shows that the skills of decomposition and debugging were used more infrequently (Table 22 & 25). This aligns with Bers and Sullivan (2015) whereby the use of robotics activities to foster problem-solving strategies in young learners can have an impact over a short period of time.

While the present intervention contributes valuable insights, it is important to acknowledge that it is a small-scale study, and further research with larger and more diverse samples would be necessary to confirm the generalisability and long-term impact of incorporating robotics into early primary education. Nonetheless, the findings of this study complement and reinforce existing research, affirming the potential benefits of integrating robotics and CT skill development into the primary school curriculum from an early age.

8.3.2 Integration and Pedagogical approach to CT skills in the Early Years

As outlined in previous studies (Section 3.4), robotics are a useful motivational tool to use for storytelling and connecting to other subject areas in the curriculum including the development of CT skills (Angeli & Valanides, 2020; Benitti, 2012; Rusk, Resnick, Berg, & Pezalla-Granlund, 2008). While robotics are indeed motivational it was the simplistic design of Bee-Bot (Appendix 4.3) which made it not only effective for promoting CT skills but also for the classroom teacher to integrate into the play session.

An observation from the study was the importance of Bee-Bot's simple design which provided the children "a way in" to developing the computational thinking skills. The Bee-Bot was easy to use, had a fun design and the children enjoyed the sounds it made when it completed a route (Section 4.3). Similar to studies conducted by Tufts University with KIBO, Bee-Bot offers quick iterations and physical representation of a program in a structured environment on the floor mat (Mihm, 2021). The Bee-Bot was significant to the development of CT skills as it either finished in the right or wrong place on the mat. The context provided lots of opportunities to practice the skills and to try and try again.

“In the coding playground, systematic debugging is part of the fun”” (Bers, 2020, p. 110). While somewhat limited in its ability to programme in comparison to other tools such as ScratchJr, KIBO, and Bee-Bot offered a real-world experience for the children where they could immediately acknowledge the impact of their instructions. The findings in Section 7.5.2.2 outline that the children enjoyed pressing the buttons on Bee-Bot and they enjoyed the times it deviated from the story route. Using Bee-Bot as an introduction to CT skills lays the foundation for further CT skill development. Mihm (2021) likens the skills used by a child programming a robotics device in junior infants to that of a software engineer. Both groups are using the same cognitive processes skills albeit on different levels of ability. Both use the devices available to move through a problem-solving process. The benefit of the robot used by the junior infants is that it does not require fluency in a programming language to control the Bee-Bot however it still provides the fundamentals of computer science such as abstraction, algorithmic thinking, debugging etc. (Mihm, 2021). The Bee-Bot provides an easy way in for the children and the classroom teacher where the environment remains fun, interactive and skills are developed with an age-appropriate device.

The research intervention integrated Bee-Bot and second language learning through a playful storytelling activity. According to Tengler et al., (2022), the integration of stories, texts, and literature with educational robotics appears to be a promising concept to equip students with the required skills. An important contribution from the research intervention is the observation of CT skills development with young learners in a mainstream class when integrated with storytelling. The CT skill framework (Table 2) was adopted and integrated during the classroom play session and the data outlines that children in Junior Infants can improve their CT skills through integration with another subject area i.e., CLIL, Language (Irish).

Tengler et al., (2022) conducted a similar study on the effect of robotics-based storytelling activities on primary school students’ CT skills. The study was conducted with third and fourth grade children (N = 40) between 9-10 years old. Their investigation to test if the integration of robotics-based storytelling activities enhanced computational thinking skills indicated an increase in computational thinking was evident after the intervention is implemented. Tengler et al., (2022) study is an indicator of how to develop language learning and robotics for primary school children. During Tengler et al., (2022) study children were retelling a familiar story such as Little Red Riding Hood and the Gruffalo by drawing a map on a white page. The children then coded their robot (Ozobot) to follow the route they had drawn. This aligns with the methodology of this intervention where the children (5-6 years old) plotted their story according to the pictures and planned a route for Bee-Bot. Similar to Bers and Sullivan (2015) analysis of second graders, Tengler et al., (2022) analysed the children's coding skills for more complex coding skills such as loops. The research intervention aligns with many elements of Tengler's approach but in particular on the final day of the six-week study. The children created their own story and planned the story using the floor map grid. It was important that the children could use readymade pictures, so their focus was on planning the story with each other, plotting the route for Bee-Bot and use their Irish language (Section 7.5.2.1).

A significant contribution from this study is that it took place in a real world setting in contrast to much of the existing research which is either in a bespoke laboratory environment or uses a team of expert adult CT educators (Sullivan and Bers, 2015). There was one teacher and 27 children in the classroom (Table 5). The teacher alone was responsible for setting up the activity, supporting the activity and overseeing the children's progress. A similar study conducted in kindergarten classrooms by Hunt and Bers (2021) over 12 weeks looked at the relationship between coding, CT skills and the contexts in which those concepts are learned. The study outlines a number of interesting results for multi-subject integration including language development. While other studies outline the establishment of similar activities in classrooms there are always a number of adults or a research team on hand (Hunt & Bers, 2021). For Hunt and Bers (2021) their study consisted of 12 lessons (once a week) where children were taught sequencing (algorithmic thinking) and more complex skills such as repeats and conditionals using KIBO. To support these lessons there was always a team of researchers on hand. This aligns with the approach taken by Sullivan and Bers (2015) and Tengler et al., (2022).
Managing the classroom when integrating a new device such a robotics can be challenging when a team of researchers are not available to support. This research intervention offers the unique perspective of the real-world context, where the learning environment changes constantly, and the teacher must adapt to the needs of the children (Stork, 2020). During the research intervention, a strategy the teacher used to manage this was to establish a set of guidelines for the play session. These play session guidelines were used each week during the place session and supported the children in understanding the parameters of their play area and the play session. The implementation of these guidelines to the support the play area during the play session was effective however given the teacher's role in the classroom she remained central to the set-up of the activity her support was required at the end of the activity. This study demonstrates how a play session can effectively integrate a robotics activity alongside other activities. Not only did the teacher integrate a robotics activity but she also

conducted one activity out of five through the children's second language. This study demonstrates that even with a large class size (27 children) it is possible to establish a play area within the play session which is designed for language and CT skill development.

8.3.3 Supporting processes

In this section, an outline is provided on the processes that supported the learning environment established during the research activity. The design of the intervention and the dynamic nature of the research design supported CT skill development during the activity. As highlighted in Section 8.2.4.2 scaffolds in the environment play an important role in supporting the learning. Some physical scaffolds were identified as crucial to the children's learning during the activity, including the story-based floor mat, the design of the robot, and the unplugged activities. The results align with the existing literature base to indicate that Bee-Bot, the floor programmable robot, is an effective tool for this age group.

8.3.3.1 Story based floor mat

The floor mat design originated from the children's daily language lessons. These lessons served as the foundation for the development of three distinct floor mat designs, each corresponding to one of the three stories covered in the Irish language lesson (Appendix J). These stories were presented in a visually engaging picture format on the respective floor mats. The design of these mats prioritised ease of use during play sessions, ensuring that both teacher and children could effortlessly swap out laminated pictures to match the evolving narratives.

The integration of storytelling and robotics has been a subject of interest in prior research. Numerous studies have explored the benefits of incorporating storytelling elements to support the development of CT skills in children (Sullivan and Bers, 2015; Tengler et al., 2022; Hunt and Bers, 2021). However, the specific implementation of these storytelling approaches can vary based on the age group of the children involved. For instance, Tengler et al., (2022) investigated CT skill development in 9-10-year-olds using fairy tales and familiar stories, with children actively creating story maps for the robot to follow. Similarly, Bers and Sullivan (2015) utilised the KIBO robot to follow a predetermined path within a themed learning environment. They constructed stories around these themes to facilitate learning. In contrast, the research intervention involving Bee-Bot in this study employed picture cards derived directly from the classroom stories. This approach was deemed appropriate for the target age group, as it provided valuable prompts for children struggling with story recall.

The inclusion of picture cards proved to be especially beneficial during the final day of the intervention when children were tasked with collaboratively creating their own narrative. These cards served as a familiar reference point, aiding the children in constructing their unique story. The support provided by the picture cards became particularly evident during this session, as the children leveraged the familiar images and language to create and share their own imaginative stories with their peers.

The research intervention design integrated storytelling elements from daily language lessons into robotics education for young children. The use of picture cards as visual aids on the floor mat effectively supported the children's engagement and participation, especially during the creative storytelling phase of the intervention. This approach adds to the existing body of research on the use of narrative in fostering CT skills development, emphasising the importance of tailoring such strategies to the specific needs and age group of the participants.

8.3.3.2 The design of the robot

In Section 4.3, the Bee-Bot's design is described. Its simplicity, playful appearance, and overall attractiveness make it an ideal choice for introducing to Junior Infants, aged 5-6. The robust construction and durable hard shell of the Bee-Bot ensure that it can withstand the rigours of the play session with young children, which is crucial for any educational tool.

What's truly remarkable about the Bee-Bot is that it's not just another digital device in the classroom. Instead, it became a cherished companion for the children, and one that motivated them to use their Irish. The directional buttons on its back are easily visible and tactile, providing a satisfying experience for the children as they interact with the robot. While the young learners may sometimes struggle to remember the sequence of buttons pressed, the Bee-Bot used in Cycle 4 provided audio for each inputted command in the Irish language. This audio feedback added an engaging and educational dimension to the experience.

Bee-Bot offered the flexibility to attach specific audio recordings to each command. In this case, it said the commands in Irish, enhancing the language-learning aspect. Not only did this help the children with their coding of Bee-Bot but it also reinforced the directional language consistently throughout the activity.

In contrast, another noteworthy educational robotics tool introduced by Hunt and Bers (2021) is KIBO. KIBO employs a different approach, where instead of directly pressing buttons, children arrange commands in the form of physical blocks, akin to coding blocks. This method encourages a structured and systematic approach to programming as children scan each block to carry out instructions.

Meanwhile, Ozobot boasts a slightly more intricate design, requiring users to understand specific colours that correspond to various actions. This design choice adds a layer of complexity that can be engaging for older learners, as noted by Tengler et al., (2022). The Ozobot's versatility is further enhanced by its ability to utilise a web interface for programming, making it a valuable tool for older students who are ready for more advanced coding experiences.

One of Bee-Bot's notable advantages is its affordability, making it a cost-effective digital tool suitable not only for the infant classroom but also for broader adoption across the entire school. This accessibility ensures that more students can benefit from the learning opportunities offered by this engaging robot.

8.3.3.3 Unplugged activities

As outlined in Table 15, the children engaged in a two-week period of unplugged activities before delving into the research activity involving Bee-Bot. Throughout this initial phase, the children were participating in activities where they assumed the roles of robots and robotics directors, engaged in table top games, and began to incorporate directional language in the context of the Irish language. In Section 7.6.1, the teacher noted that teaching directional language through these unplugged activities was a somewhat protracted process, expressing concerns that the children might not grasp the concept within the allocated two weeks. Nevertheless, she also observed that, by the end of this preparatory phase, the children were primed and eager for the forthcoming Bee-Bot challenge.

It is widely recognized across various research in the realm of robotics that the initial step involves acquainting oneself with the robot, comprehending the fundamentals of unplugged sequences or algorithms, and gaining proficiency in programming. Tengler et al., (2022) underscore this by emphasizing that their first lesson is dedicated to acquainting students with the robot, its functionalities, and the basics of programming. In the case of the children in this intervention, the unplugged activities, while initially met with some reluctance, served a genuine purpose before the research activity commenced.

As the transition to Bee-bot unfolded, it became apparent that the preceding unplugged activities laid a solid foundation. The children exhibited a remarkable ease in manoeuvring Bee-bot across the floor mat, adeptly utilizing their newfound directional language skills, and collaborating harmoniously to accomplish tasks. This seamless progression from unplugged activities to Bee-bot interaction underscored the importance of the initial phase in preparing the children for the subsequent robotics-focused research intervention.

8.3.4 Research Question 3 summary response

This study's key findings support the practicality and effectiveness of integrating robotics activities and computational thinking skill development into early primary education. The observed improvements in algorithmic thinking, debugging, and decomposition skills underscore the potential benefits of utilising robotics interventions to promote CT skills and problem-solving abilities among young learners. As such, these findings provide valuable guidance for educators seeking innovative approaches to enhance students' learning experiences in the classroom.

8.4 Domain General Processes

This study aimed to explore the use of a programmable floor robot for second language learning in the early years and the development of computational thinking (CT) skills. The researcher used a playful storytelling robotics activity as a context for language learning. The study demonstrated that the integration of robotics activities for the development of CT skills alongside second language learning yielded positive outcomes in both domains (Section 7.3.1 & 7.4.3). This suggests a potential mutually reinforcing relationship between the learning processes in these two areas.

According to Govind, Hassenfeld, and de Ruiter (2021), there are connections between coding, CT, and literacy. They state that efforts to integrate CT into traditional literacy instruction have been fuelled by technological and policy advances. This aligns with the current movement towards integration in the Irish curriculum, where the use of technological tools is encouraged across the in the classroom. Govind et al. (2021) suggest that children can use their existing literacy and language skills to support programming and algorithmic thinking. Govind et al. (2021) suggest that by utilising CT skills when learning literacy skills during the writing workshops, children can brainstorm, plan, draft, revise, and publish code using their language abilities. This research study however posits that both literacy and CT skills could develop at the same time.

Hassenfeld and Bers (2020) also outline the connection between programming and the writing process, and a similar comparison can be drawn between coding and second language development. During the robotics activity in this study, the focus was on the target language associated with the children's Irish language lesson. The use of Bee-Bot supported the children's language development and CT skills.

The observations during this study indicate that there is the potential to draw parallels between the process of CT skills development and second language learning. Children abstract relevant language for task completion from their teacher's instructions, generalise language through repetition and frequent use, use decomposition to break down sentences in Irish, and employ algorithmic thinking in sequencing words in sentences. Debugging is observed through teacher correction, peer correction, and self-correction. Future work is required in this area to definitively say that the process of CT skill development and second language learning are the same however this study indicates that there is potentially a set of common underlying processes.

Building on Papert's Constructionism and Bers development of CAL and coding stages, this research contributes a link between second language learning (a new domain for the children) and CT skills. As discussed in 3.6 CAL's approach and curriculum explore the parallels between programming and natural languages and their communicative and expressive functions.

Coding activities can engage children in thinking about powerful ideas from computer science, as well as other domains (Bers, 2019).

Similar to the framework developed by Govind et al, 2021 a draft framework for second language learning linked to CT skills is presented. The table below describes the CT framework (Angeli et al., 2016) adopted for this study and a corresponding draft framework for when these skills are developed for second language learning.

The study demonstrates the positive impact of integrating robotics activities for CT skills development with second language learning, and it highlights the parallels between CT skills and language learning. The frameworks proposed by Govind et al. (2021) and Angeli et al. (2016) serve as valuable models for understanding the relationship between CT and second language learning in the early years of education. This draft framework in Table 31, explores the possibility of integrating CT (Computational Thinking) skills into various domains, with a particular focus on language learning.

Table 28 A draft framework connecting computational thinking with second language learning

	The elements of computational thinking Angeli et al. (2016)	**The elements of computational thinking applied to language learning (incl. SCT constructs)**
Element	**Definition**	**Working definition CT and SLL**
1. Abstraction	The skill to decide what information about an entity/object to keep and what to ignore (Wing, 2011).	The skill to decide from the SL output of the teacher/expert to complete a given task or to answer appropriately in the SL.
2. Generalisation	The skill to formulate a solution in generic terms so that it can be applied to different problems (Selby, 2014).	The skill to use generic phrases so that they can be applied to different conversations during various learning experiences through internalisation.
3. Decomposition	The skill to break a complex problem into smaller parts that are easier to understand and solve (National Research Council, 2010; Wing, 2011).	The skill to break down an oral language utterance into smaller parts so that the intention is easier to understand.

4. Algorithms a. Sequencing b. Flow of control	The skill to devise a step-by-step set of operations/actions of how to go about solving a problem (Selby, 2014). The skill to put actions in the correct sequence (Selby, 2014). The order in which instructions/actions are executed (Selby, 2014).	The skill to devise and implement sentence structuring orally during second language learning. The skill to formulate sentences in the correct format, delivering a clear and coherent message.
5. Debugging	The skill to identify, remove, and fix errors (Selby, 2014).	The skill to rephrase an output error during oral language and correct it. This can be supported by the MKO.

The framework presented here is a preliminary hypothesis derived from the discussions in this section and section 8.3. The positive learning outcomes observed during the research intervention demonstrate the potential benefits in a practical setting for junior infants. However, it is essential to acknowledge that this framework is based on initial findings and requires further investigation through additional cycles of research.

8.5 Conclusion

This chapter has explored the important findings in this study relating to each research question and positioned the findings in relation to the literature. Experiencing a playful learning activity, which included a colourful robot promoted a positive attitude amongst the children towards second language development while also discreetly developing CT skills. This motivation and positive outlook can be further developed through consideration of the children's agency during the activity as indicated on the final day of the intervention. The small scale of the cohort and short duration of the intervention limit the generalisability of the results. However, the positive indicators demonstrate that this research provides valuable insight for integration of second language learning and CT skills. Participation in the intervention transformed children's experience of Irish language learning and they were encouraged to ask questions and extend their language outputs. It is intended that this research will make a positive contribution towards the ongoing discussion on how to improve the connection between language learning skills and CT skills through the connecting elements identified in Table 31. The results of this design-based research activity indicate that the integration of robotics into the classroom through play was effective and presented a positive outcome for second language learning and teaching, however there were a number of processes, which supported this positive outcome. The research activity was integrated into the classroom through a designated time for play and all children were participating in various play activities during this time. This way of integrating new activities into the classroom is effective in the early years as it is a comfortable, challenging, and creative environment for the children. The children can work collaboratively with one another or individually as they explore and use new objects in their environment. One of the most significant contributions of this study is that it took place in a real-world setting, the mainstream classroom. Not only was the activity integrated into the classroom timetable it was also successful in its aim to support language development and CT skills development. The intervention was achieved with the resources of the classroom alone – the teacher and the children working together without the outside support of a research team. This demonstrates the feasibility of this approach in a real-world setting.

The next chapter will provide an overall summary of the implications of this research, along with some recommendations for policy, practice, and future work.

9 Conclusion and Recommendations

This chapter revisits and examines the aims of the study presented in Chapter 1. Section 9.2 looks at the contributions of the study to the field of education. Recommendations for practice and policy presented in Section 9.3, and suggestions for future research in Section 9.4, followed by the chapter conclusion in Section 9.5.

9.1 Introduction

The first chapter of this thesis outlined the principle aims of this research:

- To explore the second language learning process through a play-based intervention.
- To explore the impact of a play-based robotics-based intervention on children's computational thinking skills
- To explore children's attitudes towards learning Irish during a playful storytelling activity, facilitated by a floor programmable robot
- To make a meaningful contribution to the wider policies and practices related to language learning in schools, particularly in the context of minority languages.

This research activity was the culmination of a language learning experience drawing together second language learning and computational thinking skills. With an effective impact on second language learning, the use of robotics proved to be an effective tool for not only supporting second language learning but also for introducing computational thinking skills to children in the early years of primary school. The use of dynamic scaffolding within the learning environment also contributed the development in both disciplines. The robotics intervention was designed to promote second language learning, underwent four successful Design-Based Research cycles. The research findings indicate that this approach can effectively facilitate meaningful interaction in language and computational thinking skill development, while also serving as a motivating factor for children learning a second language. Moreover, the activity can be integrated into the classroom environment, provided that adequate support is provided to the children. Notably, social engagement and scaffolding from the teacher and peers play a crucial role in its success.

Section 9.2 will outline the significant contributions of this thesis, followed by recommendations for practice, policy in Section 9.3. Section 9.4 will provide an overview of future research.

9.2 Contributions of this study

This thesis contributes significantly to the field of language learning and Computational Thinking (CT) with a specific focus on the Irish education context.

- Employing a sociocultural framework, the research explored the impact, integration, and attainment factors of language learning in primary schools, utilising various data sources to provide comprehensive insights.

- Moreover, the research delves into the dynamic role of the More Knowledgeable Other (MKO) in the learning process, highlighting its significance for teachers in adapting their teaching strategies accordingly.

- A structured data coding framework was developed and applied to data transcripts using CHILDES coding software, enhancing the precision and consistency of data analysis. Provides an in-depth study of Irish language learning during early primary English medium education, an area where these is a dearth of evidence The study advances evidence-based research on second language learning, particularly regarding oral language development during early primary years.

- Additionally, the application of child assent and child voice methodology in Design-Based Research user consultation ensures a more inclusive and participatory approach, gaining valuable perspectives from young learners.

- The research successfully establishes a playful context for language use, offering opportunities for second language learning in early primary education, fostering a positive learning environment for young children.

- It also explores the applicability and integration opportunities for CT skills within the early years of primary school, shedding light on the potential of combining CT education with language learning.

This thesis also highlights the significance of translanguaging in the context of minority languages, specifically the Irish language. The research uncovers that translanguaging, where the teacher and the children fluidly switch between languages to communicate effectively, may play a crucial role in the context of Irish language education. As a minority language, Irish faces challenges in usage and preservation, however as children engage in translanguaging they begin to develop a deeper connection with the language, bridging their native language with Irish and fostering a sense of linguistic identity. Furthermore, promoting translanguaging in educational settings can create a more inclusive and supportive learning environment for language learners and teachers, dispelling negative perceptions associated with the Irish language. Embracing translanguaging becomes paramount in preserving the Irish language and supporting its vitality in a multilingual society.

Incorporating children's assent in research interventions is a crucial ethical consideration, and its significance cannot be undermined in contemporary times. Informed assent empowers children by providing them with the knowledge and agency to make decisions regarding their participation in research activities (James & Prout, 2015). This aligns with the principles laid out in the United Nations Convention on the Rights of the Child (UNCRC), emphasising the right of children to express their views freely in matters affecting them (United Nations, 1989).

The findings of this study highlight that the children appreciated being asked for their assent, which contrasts with common practices where parental consent is sought, and children remain unaware of their involvement in research endeavours (Smith et al., 2019). By seeking their assent, researchers validate children's perspectives and recognise them as active participants in the research process (Morrow, 2016). Such inclusion fosters a sense of respect and autonomy, which can contribute to a more meaningful and ethical engagement with young research participants.

Moreover, the study revealed that some children expressed discomfort with being filmed, underscoring the importance of assent in acknowledging individual differences and preferences among children (Fargas-Malet et al., 2010). Respecting their choices not to be on camera is vital in upholding their rights and well-being during the research process (Iphofen, 2018). The act of seeking children's assent serves as an essential ethical safeguard in research, ensuring that their rights and voices are recognised and respected throughout the research intervention (Alderson & Morrow, 2011). By adhering to the principles of informed assent, researchers can foster a more inclusive and child-centred approach to research, promoting the overall well-being and participation of young participants (Lundy et al., 2012).

9.3 Recommendations for practice and policy

This section will present recommendations for practice and policy based on the findings from this study.

This research activity represents opportunity to implement Content and Language Integrated Learning (CLIL) in the early years of primary school. The Department of Education (2019) has implemented a three-year CLIL pilot project which sees Physical Education along with other subjects taught to children across different age groups through Irish. During this research activity, the children used their Irish language as they explored new content related to CT skills, coding, and technology. There was an increased exposure of Irish by extending the use of Irish as the medium of communication and instruction from the teacher in a real and practical context; they moved beyond the Irish language lesson. The results reflected motivation and knowledge in both their Irish language and CT skills applicability and the development of their learning and communication strategies. It is recommended that the use of CLIL in the classroom move beyond the traditional subject areas of Physical Education and Art and a creative approach taken in the early years of primary school to incorporate useful technological tools that give children the opportunity to use their new language in a practical and real way through “CLIL showers”.

Considering the literature review and research findings, it is evident that textbooks, programs, and ready-made templates for teaching are widely employed by teachers and schools. While these resources can provide support, it is crucial for educators to recognise that they should serve as supplementary tools rather than prescriptive mandates for all instructional practices. Currently, some schools implement these materials comprehensively in their whole school plan for teaching Irish, facilitating management's tracking of learning outcomes and themes across different year groups. However, this reliance on textbooks may hinder teachers' agency and flexibility to adapt their teaching approaches based on the specific needs of their students. Therefore, it is recommended that educational practices be reviewed to examine the role of textbooks in schools and assess whether their pervasive use may inadvertently limit teachers' autonomy and creativity in the classroom.

This research recognises the potential relationship between Computational Thinking (CT) skills and language learning during activities involving technological devices like robots. Bers (2020) argues that coding qualifies as a new literacy akin to other languages, given its significance as a 21st-century skill. As the National Council for Curriculum and Assessment (NCCA, 2023) develops a new primary school curriculum, coding has found its place within the STEM (Science, Technology, Engineering, and Mathematics Education) curriculum area. It is important to recognise the possible connection between coding and the Language Curriculum, and how coding could potentially emerge as a new literacy that intersects with the learning outcomes of the language curriculum. By integrating coding into the language curriculum, the education system could promote interdisciplinary learning experiences, bridging the gap between STEM and language education, and fostering innovative approaches in the digital era.

Consideration should also be given to tools with which CT skills can be demonstrated in the early years of primary and also encourage the use of practical technological tools in the early years. Children in stages 1-2 of primary school are often left behind in terms of advancement in the area of technology for various reasons. The subject area of technology, the integrative opportunities it offers, and the methodology itself should have a central place in our modern-day curriculum and teachers should be encouraged to use it through continuous professional development and agency in their own classrooms.

9.4 Future Research

This research contributes significantly to the existing body of knowledge pertaining to the realms of second language learning and the development of CT skills in early childhood education. Beyond its academic implications, this study holds substantial practical relevance for curriculum developers, instructional leaders, and classroom educators. They can utilise the insights garnered from this research to inform the design of curricula and classroom activities, specifically emphasising the integration of CT skills and storytelling as a means to foster the use and appreciation of the Irish language.
This section will now elaborate on potential avenues for future research in three key areas: translanguaging, Content and Language Integrated Learning (CLIL), and the examination of the domain general processing framework (Section 8.4).

1. Translanguaging and the Irish language: The study has underscored the lack of research in the domain of translanguaging concerning the Irish language. There is a need for further exploration and understanding of how translanguaging can be effectively employed to facilitate language learning, language use, and language appreciation in the context of Irish.

2. The use of CLIL in the early years of primary school: While the study has demonstrated the value of CLIL in infant classrooms for seamlessly integrating a second language with other subjects, such as storytelling, it is important to recognise that research on this topic in the context of the Irish language at the early primary level remains limited. Consequently, there is an opportunity for extensive research into the application and benefits of CLIL within the Irish

primary education setting. As the Primary Language Curriculum Framework (NCCA, 2023) outlines a reduced time allocation to the Irish language it is recommended that CLIL is investigated as way to promote the language through integration with other subject areas.

3. Integration of robotics during play sessions in early primary education: The study's investigation into the integration of robotics and storytelling in early childhood classrooms offers promising insights. However, this area calls for more extensive research on a broader scale, encompassing various schools and settings. Such research can provide further insights on the potential benefits and challenges associated with integrating robotics into early education, thereby guiding educators and policymakers in this domain.

4. Investigation of the draft framework connecting computational thinking with second language learning: Section 8.4 of the study has introduced a draft framework that draws parallels between CT skills and second language learning. To gauge the practicality and effectiveness of this framework, there is a need for a larger-scale study that encompasses diverse educational contexts. Such research would not only validate the framework but also help refine it for broader application.

This research is a significant contribution to the field of second language learning and CT skills development in early education. However, it also serves as a launchpad for future inquiries in translanguaging, CLIL, robotics integration, and the application of the computational thinking framework, ultimately enhancing our understanding of effective language learning strategies and innovative pedagogical approaches in early primary education.

9.5 Conclusion

The successful integration of language learning and the development of computational thinking (CT) skills was achieved through an extensive process comprising four Design-Based Research iterations, three pilot cycles, and one full cycle conducted in a junior infant class.

This research yielded the development of a language learning activity that combines Irish language learning with the development of CT skills within an early years' primary classroom setting, all achieved through a play-based methodology. The results obtained from this research activity strongly suggest that this approach can be highly effective in establishing an environment conducive to meaningful interactions among students, motivating children, and fostering the development of various CT skills. Importantly, this innovative approach presents teachers in English medium schools with a valuable opportunity to facilitate children's Irish language proficiency while simultaneously integrating it with other subjects in the curriculum.

Given the ongoing efforts of educators and schools to promote the use of the Irish language throughout the school day, this research intervention highlights a practical method by which children can naturally engage with their second language through a "soft CLIL" approach. By creating an engaging context for children to use the language, particularly through storytelling with the support of a robotics tool, it not only boosts their motivation to learn the language but also instils their Irish language lessons with a sense of purpose, as they understand its relevance in the context of the Bee-Bot activity. This research underscores that a task-based approach, featuring cooperative group work, has the potential to generate enjoyable language learning activities tailored to young children, further enhancing their language learning experience.

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Appendices

Appendix A The six stages of coding

The six stages of coding that measure a child's development with coding (Adapted from (Bers, 2020, pp. 67-68)

Coding stage	Concepts	Indicators
Emergent	The child recognises that technologies are human engineered, understand the concept of symbolisation, and has familiarised themselves with the interface; but is only beginning to explore the programming language (only knows the meaning of some symbols)	• The child knows how to turn the tools on and off and is able to correctly interact with the interface. • The child knows that a human programmer wrote the command or program- does not treat the tool as an autonomous entity. • The child knows that a command represents a behaviour. • The child knows that a basic control structure exists.
Coding and decoding	The child understands that sequencing matters and that the order in which commands are put together generates different behaviours. They have learned a limited set of symbols and grammar rules of the programming language and have begun to identify and fix grammatical errors in the code. The most growth can be seen at this stage.	• The child can correctly create simple programs with simple cause and effect commands • The child engages in goal-oriented command exploration • The child performs simples debugging through trial and error • A child can identify and fix grammatical errors in the code
Fluency	The child has mastered the syntax of the programming language. The child understands how to distinguish and fix logical errors in the code. (i.e., a program runs, but it doesn't do what is expected)	• The child is personally motivated to create complex programs using control structures. • The child can correctly create complex programs using control structures. • The child is beginning to be strategic with how they debug. • The child can distinguish and fix logical errors in the code.

New Knowledge	The child understands how to combine multiple control structures and create nested programs that achieve complex sequencing.	• The child engages in more goal-oriented logical exploration with their programs. • The child is personally motivated to create nested programs to achieve complex sequencing. • The child can correctly create nests programs to achieve complex sequencing. • The child is strategic with how they debug.
Multiple perspectives	The child understands how to create programs that involve complex user or tool interactions.	• The child can create programs that involve the user's input. • The child can create multiple programs that interact with one another. • The child is beginning to analyse, synthesise, and translate abstract concepts into code. • A child can debug multiple control structures.
Purposefulness	The child understands how to analyse, synthesise, and translate abstract concepts into code. The child is coding skilfully for their needs and purpose.	• The child is personally motivated to create complex programs. • A child can analyse, synthesise, and translate abstract concepts into code. • After translating abstract concepts into code, the child can correctly translate their code back into their abstract concepts. • The child is able to identify multiple ways to translate abstract concepts into code.

Appendix B Principal Information Sheet and consent

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Principal Information Sheet

November 2018

Dear Principal,

I am currently undertaking a part-time PhD in the School of Education, Trinity College Dublin. As part of this course, I am conducting research on the area of language learning in the early years of Primary School. My research is under the supervision of Dr Ann Devitt and is entitled *Floor robots: a motivating tool for language learning in the early years of Primary School*.

This project focuses on children using and interacting with a floor robot to learn Irish. This is an innovative methodology to engage children with Irish and computational thinking, thereby addressing the demands of the new language and new maths curriculum. During Aistear, an additional area will be established for the floor robots where groups of children can move the floor robot around maps. These maps will display pictures and words in Irish - the target language being taught. A video camera will be placed over this area so that the children's interactions can be recorded. The classroom teacher may also take still images of the children playing with the floor robots. The data collection for the project will include these recordings and images, together with pre- and post-activity questionnaires and video-recorded interviews with the classroom teacher and a focus group of children. It is anticipated that the entire study will be completed during school hours over a six-week period. By incorporating the floor robots into Aistear, I hope to minimise any disruption in the classroom.

I am aware that this is a very busy time of year for you and your school, and I would greatly appreciate your assistance with this project. I can foresee no risks being associated with individual and school participation in this six-week study beyond those experienced in everyday life. The information gathered will be treated with the appropriate privacy and anonymity. No information about your school or the participants will be identifiable in the research. All information will be securely stored with access available only to the research team and examiners. Any personal identifying information will be anonymised. The results will be included in a thesis and may be discussed at conferences or published in the academic literature. Some anonymised data – for example, images or recordings – may be used during such presentations but all data will be destroyed after a period of eight years. As a site for data collection, a copy of the results would be made available to your school on request.

Please note that neither your school nor the pupils are under any obligation to participate in this study. If at any time a pupil wishes to withdraw from the study, they may do so, up until the preliminary analysis of the data is complete. Children whose parents do not consent to their participation in the research project will continue to participate in the research activity, but no data will be collected on their engagement with it.

If you have any further questions regarding this research, please do not hesitate to get in touch using the email addresses provided below. Finally, I would like to thank you for taking the time to consider this proposal. Without your generous participation, conducting such research would be impossible.

Kind Regards,

Susan Nic Réamoinn

Principal's consent form

I have read and understood the information sheet included with this consent form and I am happy for Susan Nic Réamoinn to conduct research in (class) in (school) over six weeks.

Principal's signature: ___________________________

Date: _________________________

Researcher's signature: ___________________________

Date: __________________________

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Teacher Information Sheet

November 2018

Dear Teacher,

I am currently undertaking a part-time PhD in the School of Education, Trinity College Dublin. As part of this course, I am conducting research on the area of language learning in the early years of Primary School. My research is under the supervision of Dr Ann Devitt and is entitled *Floor robots: a motivating tool for language learning in the early years of Primary School*.

This project focuses on children using and interacting with a floor robot to learn Irish. This is an innovative methodology to engage children with Irish and computational thinking, thereby addressing the demands of the new language and new maths curriculum. During Aistear, an additional area will be established for the floor robots where groups of children can move the floor robot around maps. These maps will display pictures and words in Irish - the target language being taught. The pictures and words will link to the current topic being taught in your classroom. A set of lesson plans and resources will be provided for the duration of the research project. A video camera will be placed over this area so that the children's interactions can be recorded. You may also take still images of the children playing with the floor robots. The data collection for the project will include these recordings and images, together with pre- and post-activity questionnaires and recorded interviews with you and a focus group of children. You are asked to keep a reflective diary where you record general observations. For example, you might reflect on any changes in the use of language, attitude towards the language or developing proficiency in the coding of the robot. It is anticipated that the entire study will be completed during school hours over a six-week period. By incorporating the floor robots into Aistear, I hope to minimise any disruption in the classroom.

I am aware that this is a very busy time of year for you and your school, and I would greatly appreciate your assistance with this project. I can foresee no risks being associated with individual and school participation in this six-week study beyond those experienced in everyday life. The information gathered will be treated with the appropriate privacy and anonymity. No information about your school or the participants will be identifiable in the research. All information will be securely stored with access available only to the research team and examiners. Any personal identifying information will be anonymised. The results will be included in a thesis and may be discussed at conferences or published in the academic literature. Some anonymised data – for example, images or recordings – may be used during such presentations but all data will be destroyed after a period of eight years. As a site for data collection, a copy of the results would be made available to your school on request.

Please note that the pupils in your class are under no obligation to participate in this study. If at any time a participant wishes to withdraw from the study, they may do so, up until the preliminary analysis of the data is complete. Children whose parents do not consent to their participation in the research project will continue to participate in the research activity, but no data will be collected on their engagement with it.

If you have any further questions regarding this research, please do not hesitate to get in touch using the email addresses provided below. Finally, I would like to thank you for taking the time to consider this proposal. Without your generous participation, conducting such research would be impossible.

Kind Regards,

____

____

Student email Supervisor email

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Teacher's consent form

1.	I ________________ (Teacher's name) have read and understood the information sheet included with this consent form and I am happy for Susan Nic Réamoinn to conduct research in (class) in (school) over six weeks.
2.	I give consent for; Photographs of me to be taken during the research activity by the researcher ☐ Yes, I give consent ☐ No, I do not give consent Video recordings of me engaging with children during the research activity ☐ Yes, I give consent ☐ No, I do not give consent An audio recorded interview ☐ Yes, I give consent ☐ No, I do not give consent
3.	I give consent to maintain a general observations diary about the children's engagement with the activity. ☐ Yes, I give consent ☐ No, I do not give consent
4.	I give consent to the researcher to use photographs I take of the research activity for; Research analysis ☐ Yes, I give consent ☐ No, I do not give consent Research presentations ☐ Yes, I give consent ☐ No, I do not give consent Research publications ☐ Yes, I give consent ☐ No, I do not give consent
Teacher's signature: ______________________ Date: ____________________ Researcher's signature: ______________________ Date: _____________________	

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Parent/Guardian Information Sheet

The Researcher

My name is Susan Nic Réamoinn. I am a primary school teacher and a PhD candidate in Trinity College, Dublin. I am really interested in using technology in the primary school classroom for language learning. My supervisor for this piece of research is Dr Ann Devitt. She is an Assistant Professor of Modern Languages at the School of Education in Trinity College Dublin. Ann's research interests lie in language teaching and learning, and technology enhanced learning.

I (the Researcher) have undergone the Garda Vetting procedure and have received clearance to work with young children. This information will be made available to the school.

The research topic

This research will examine how using robots can help children learn Irish and computational skills Aistear (play based learning). The activity is focused on children using floor robots during play and how that supports and motivates them with their language learning.

The activity

An activity area will be established in the classroom where children can use the floor robot. The children will be able to programme the robot to move around specially designed floor maps that are linked with their Irish language lessons. The children will have an opportunity to engage with this activity on a weekly basis in their classroom over a six-week period.

What data will I gather?

1. Questionnaire completed with children
2. Video of the classroom activity and children's interaction with each other
3. Photos taken by teacher and researcher
4. Video of focus group discussion with teacher and researcher
5. Teacher's observation diary during the activity.

A questionnaire will take place before and after the activity. These questions ask what the child thinks about learning Irish and using technology to help them learn. Questionnaires will be anonymised. During the classroom activity a video camera will be set up to record the children's interaction with each other and the floor robot. The teacher and the researcher will take photos of the activity also. At the end of the 6 weeks children will be asked to participate in a focus group about the activity. The teacher will always be present during the activity and the focus group. Children's names will <u>not</u> be included. Questionnaires are anonymised, and images and recordings will not have names attached to them and will comply with school policy. The teacher will maintain a reflective diary where they will record general observations on the research activity.

How will this data be used?

Data collected (questionnaire, video, photos, video of focus group and teacher's observations) will be used for analysis of the research questions, thesis publication and doctoral presentations. The anonymised results will be included in a thesis and may be discussed at conferences or published in academic literature. As your child's school would be the site for data collection, a copy of the results can be made available to the school principal upon request.

Where will this data be stored?

The information gathered will be treated with the appropriate privacy and anonymity. No information about your child's school or your child, will be identified in the research. All information will be stored safely with access only available to the research team and examiners. All images gathered will comply with school policy on data storage and in accordance with the General Data Protection Regulation at Trinity College, Dublin. Data gathered from this research project will kept from eight years and then destroyed. Eight years is the amount of time chosen to keep the data collected to allow for thesis completion and post-doctoral publications.

Research consent

I wish to seek your permission for your child to participate in the research activity. Participation in the research activity is voluntary and you may remove your child from the process at any time, for any reason without consequence. Any information gathered such as questionnaire, images and recordings will not be used for the final analysis. Withdrawal from the activity is only possible up until the data is collected and anonymised. Once the data has been collected and anonymised withdrawal is no longer possible. If you have any further questions regarding this research, please do not hesitate to get in touch using the email addresses provided.

Contact details

Researcher Susan Nic Réamoinn: nicramos@tcd.ie
Supervisor Dr Ann Devitt: devittan@tcd.ie

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Parent consent form for child's participation: Parents'/Guardians' Copy

Please keep this form for your own records and return the one below to the class teacher.

I give consent to ________________________________ (child's/student's name) to participate in the research project outlined above over six weeks.
I give consent to my child to participate in; Questionnaire before and after the research activity ☐ Yes, I give consent ☐ No, I do not give consent Photographs during the activity by the class teacher and the researcher ☐ Yes, I give consent ☐ No, I do not give consent Video recordings of them engaging with the activity ☐ Yes, I give consent ☐ No, I do not give consent A video recorded focus group ☐ Yes, I give consent ☐ No, I do not give consent
I give consent for my child's teacher to maintain a reflective diary where they record general observations about my child's interaction with the research activity. ☐ Yes, I give consent ☐ No, I do not give consent *No child's name will be used in this diary.*
I give consent to the researcher to use my child's photograph and recordings in; Research presentations ☐ Yes, I give consent ☐ No, I do not give consent

I give consent to the researcher to use my child's photograph in; Research publications ☐ Yes, I give consent ☐ No, I do not give consent
Signed: ______________________ (Parent/Guardian) Date: ____________________

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The University of Dublin

Child assent form for participation: Parents'/Guardians' Copy

You do not need to fill this in with your child. This is the same assent form that your child will fill in school after they have had a discussion with their teacher and the researcher about the activity and data collection.

Your name	
Would you like to take part in an activity using robots?	☺ ☹
Are you happy to have a camera recording you?	☺ ☹
Are you happy to talk to Susan and your teacher about the activity when it's finished?	☺ ☹

PLEASE RETURN TO TEACHER

Parent consent form for child's participation: Researcher's copy

This copy will be kept by the Researcher for their own records.

I give consent to ________________________________ (child's/student's name) to participate in the research project outlined above over six weeks.
I give consent to my child to participate in; Questionnaire before and after the research activity ☐ Yes, I give consent ☐ No, I do not give consent Photographed during the activity by the class teacher and the researcher ☐ Yes, I give consent ☐ No, I do not give consent Video recordings of them engaging with the activity ☐ Yes, I give consent ☐ No, I do not give consent A video recorded focus group ☐ Yes, I give consent ☐ No, I do not give consent
I give consent for my child's teacher to maintain an observations diary about my child's interaction with the activity. ☐ Yes, I give consent ☐ No, I do not give consent *No child's name will be used in this diary.*
I give consent to the researcher to use my child's photograph and recordings in; Research presentations ☐ Yes, I give consent ☐ No, I do not give consent

I give consent to the researcher to use my child's photograph in; Research publications ☐ Yes, I give consent ☐ No, I do not give consent
Signed: ______________________ (Parent/Guardian) Date: ____________________

Trinity College Dublin
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The University of Dublin

Child assent form for participation

You do not need to fill this in with your child. This is the same assent form that your child will fill in school after they have had a discussion with their teacher and the researcher about the activity and data collection.

Your name	
Would you like to take part in an activity using robots?	☺ ☹
Are you happy to have a camera recording you?	☺ ☹
Are you happy to talk to Susan and your teacher about the activity when it's finished?	☺ ☹

Appendix F Child Information Poster

Trinity College Dublin
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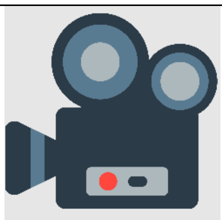
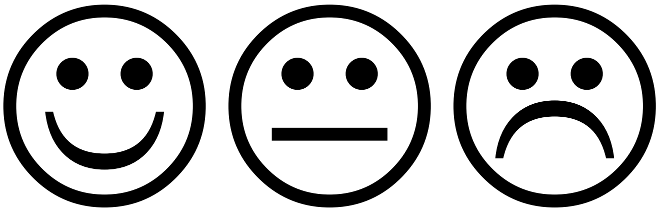
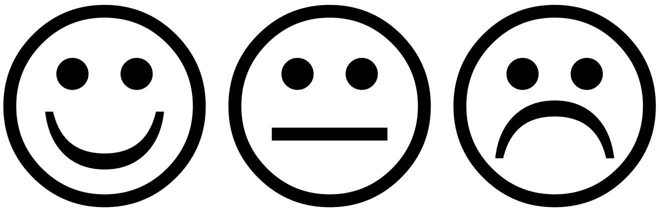
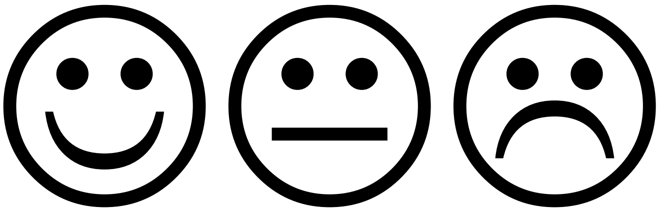
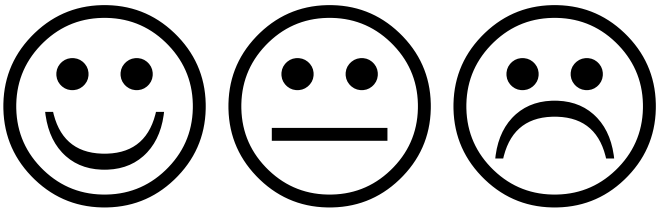
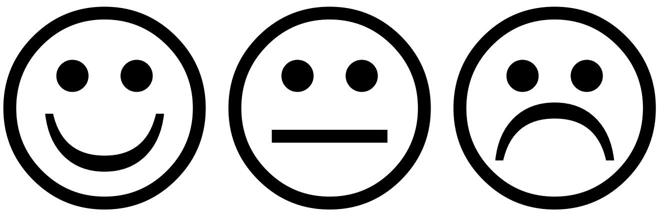
The University of Dublin

Child Information Poster

This information poster will be given to the children before seeking their assent. The poster will also be hung on the wall of the classroom so that that they are reminded regularly of the purpose of the activity and their right to not have their photo taken or participate in the recording.

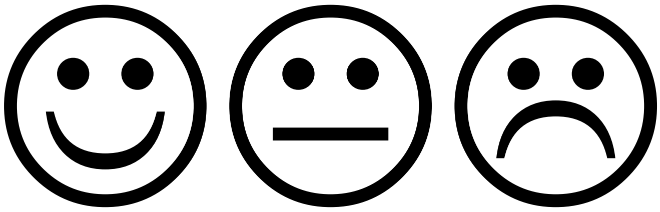
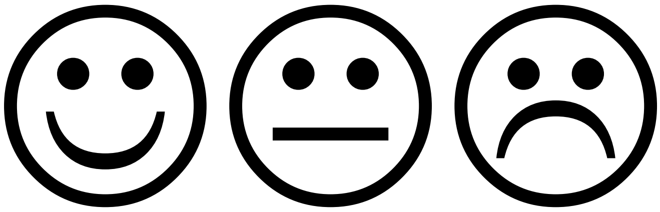
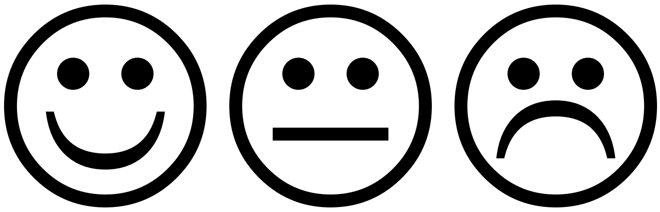
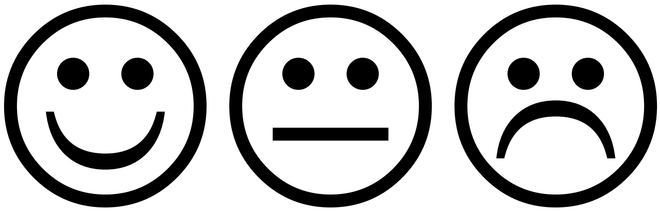
1.		**What's happening today?** Activities with some robots to help me learn Irish
2.		**Video camera** When we're using the robots, a camera will be taking a video.
3.		**Photographs** When we're using the robots, our photo might be taken.
4.		**Chat time** We're going to have a chat about the robots with Susan and our teacher.
5.		**If you don't want to be on camera** I will tell Susan or my teacher if I don't want to be in a photo or a video.

Appendix G Pre intervention questionnaire

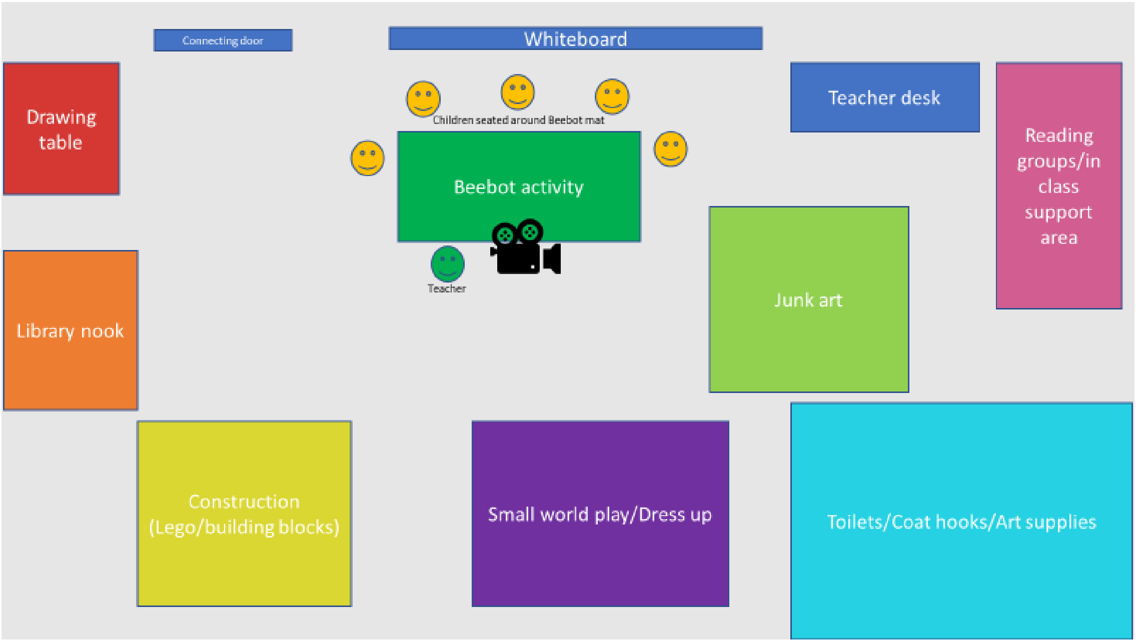
Participant's Code	
I like learning Irish	
I like using my Irish words	
I have lots of chances to use my Irish words	
We use technology to learn Irish	
Technology makes me want to learn more	

Appendix H Post-intervention questionnaire

Participant's Code	
I like learning Irish	☺ 😐 ☹
I like using my Irish words	☺ 😐 ☹
I have lots of chances to use my Irish words	☺ 😐 ☹
We use technology to learn Irish	☺ 😐 ☹
Technology makes me want to learn more	☺ 😐 ☹

I **talk** to the robot in Irish	
Is using robots to robots to learn Irish **fun**?	
Robots help me to **learn** more Irish.	
Robots make me want to **use** more Irish.	

Appendix I Classroom layout during research activity



Appendix J Target language from Irish language lessons

Teidí sa pháirc (Teddy at the park)	Bia (Food)	Na Trí Mhuicín (The three little pigs)
an pháirc ceann súil lámh glúin cos carr dochtúir leaba bindealán ag caoineadh ghortaigh sé teidí a haon a dó a trí a ceathair a cúig	ceapaire uisce ag ithe ag ól ciseán milseán uachtar reoite seacláid sú oráiste ocras tart	na Trí Mhuicín an mac tíre an teach tuí an teach adhmad an teach bríce pota uisce te

Gníomhaíochtaí Díphlugáilte - Gníomhaíocht 1 Teanga Treorach le Teidí

Róbait (teanga threorach) 10/15nóiméad

Aidhm: Na páistí a spreagadh chun cód a leanúint mar rang.

Téamh suas: Le chéile canfaidh an rang an t-amhrán Tá Teidí ag siúl, Tá Teidí ag léim srl agus beidh gníomhaíochtaí éagsúla san áireamh. Cuirtear an sprioctheanga nua in aithne do na páistí ansin sula leanann siad ar aghaidh leis an ngníomhaíocht. Áiseanna ar fáil.

B'fhéidir go mbeadh a fhios ag na páistí cad iad na treoracha seo ina gcéad teanga. Spreag na páistí leis na treoracha a roinnt ina gcéad teanga agus tú ag cur an treotheanga Ghaeilge in aithne dóibh.

Gníomhaíocht: Cuir Bee-Bot i láthair do na daltaí, agus déan cuir síos ar conas a ghluaiseann Bee-Bot. Caithfidh na páistí a thuiscint nach féidir leis ach céim amháin a ghlacadh ag an am agus ní mór é a threorú chuige sin. Caithfidh siad an teanga Bee-Bot a fhoghlaim le bheith in ann Bee-Bot a úsáid le linn súgartha. Abair leis na páistí go bhfuil siad chun ligean orthu féin gur Bee-Bot iad agus go gcaithfidh siad na treoracha a thugtar dóibh a leanúint.

Múnlaigh treoracha a thabhairt agus léirigh do na páistí na treoracha seo a leanúint. Nuair a bheidh sé seo múnlaithe, spreag na páistí chun treoracha a thabhairt. Cabhróidh sé seo leo an sprioctheanga a úsáid. Tugtar cuireadh do na páistí seasamh suas agus páirt a ghlacadh sna gníomhartha. Is féidir leis an rang leanúint ar aghaidh mar ghrúpa ag leanúint treoracha simplí agus trí níos mó treoracha a chur leo éireoidh siad níos eolaí ar an teanga. Is féidir póstaeir a chur ar an gclár bán chun tacú leis na treoracha.

- Tá Bee-Bot ag siúl chun tosaigh
- Tá Bee-Bot ag siúl siar
- Tá Bee-Bot ag casadh ar dheis
- Tá Bee-Bot ag casadh ar chlé
- Tá Bee-Bot ag glacadh sos

Nuair a bheidh na páistí eolach ar an teanga is féidir seicheamh a fhorbairt ag baint úsáide as na póstaeir balla.

Don cheacht tosaigh seo ba chóir go ndíreofaí ar chéim amháin ag an am a ghlacadh.

Conclúid: Tugtar cuireadh do na páistí Deir Ó Ghrádaigh a imirt. Ba chóir deis a thabhairt do pháiste amháin in aghaidh an bhabhta áit an mhúinteora a ghlacadh. Spreagtar na páistí an treo teanga nua ón ngníomhaíocht a úsáid.

Appendix L Sample Lesson Play Session

Seisiúin Súgartha: Seachtain 1 Téama**:** Mé féin

Ainm an cheachta: Bee-Bot ag insint scéal Teidí Beag Álainn

Torthaí Foghlama (Teanga ó Bhéal):	**Fócas na foghlama**
TF1: Rannpháirtíocht, éisteacht agus aird TF3: Gnásanna sóisialta agus feasacht ar dhaoine eile TF5: Stór focal *Curaclam Teanga na Bunscoile	Spéis agus comhaird a léiriú Feidhmiú mar chuid de ghrúpa agus roinnt focail/frásaí Gaeilge á núsáid. Éisteacht le cainteoir agus leideanna éagsúla ar nós geáitsí, fíorábhar, nó tuin chainte a úsáid chun teacht ar an bpríomhtheachtaireacht. Úsáid a bhaint, le linn spraoi agus comhrá as roinnt focail/frásaí Gaeilge bunúsacha a chloiseann siad go minic.

Cuspóirí/Feidhmeanna Teanga:

Ba chóir go gcuirfí ar chumas an páiste:

- Éisteacht le hamhrán agus é a chasadh
- Gníomhaíochtaí a aithint
- Tuairisciú

Cuspóirí Smaointeoireachta Ríomhaireachtúla (Computational thinking):

Ba chóir go gcuirfí ar chumas an páiste:

- Socraigh bealach do Bee-Bot
- Cuir na treoracha isteach i Bee-Bot san ord ceart
- Bris síos an bealach isteach más gá
- Pléigh agus ceartaigh aon fhadhbanna a thagann chun cinn

Eiseamláirí:

Ghortaigh sé a _______(cheann. shúil, lámh, ghlúin)

Thit Teidí sa pháirc.

Tá Teidí ag caoineadh.

Foclóir: An pháirc, ceann, súil, lámh, glúin, carr, dochtúir, leaba, bindealán, ag caoineadh, ghortaigh (sé)

Teanga an mhúinteoir (Ceacht Gaeilge)	**Teanga an dalta (Ceacht Gaeilge)**
Taispeáin dom do cheann Taispeáin dom do ghlúin/ghlúine Taispeáin dom do lámh/lámha Taispeáin dom do shúil/shúile. Teidí bocht.	Ghortaigh sé a cheann Ghortaigh sé a shúil/shúile Ghortaigh se a lámh Ghortaigh sé a ghlúin Seo é mo cheann Seo é mo shúil Seo é mo lámh/lámha Seo é mo ghlúin/ghlúine
Teanga an mhúinteoir (Tacú le Bee-Bot a úsáid)	**Teanga an dalta (Úsáideadh an teanga seo le linn na Gníomhaíochtaí Díphlugáilte)**
Cá bhfuil Bee-Bot ag dul? Cad é an chéad chéim eile? Cad a tharla ina dhiaidh sin sa scéal? An gá do Bee-Bot casadh ar dheis? An gá do Bee-Bot casadh ar chlé? An gá do Bee-Bot céim chun tosaigh a thógáil? An gá do Bee-Bot céim siar a ghlacadh?	Tá Bee-Bot ag dul go dtí.... Caithfidh Bee-Bot casadh ar chlé. Caithfidh Bee-Bot casadh ar dheis. Caithfidh Bee-Bot céimm ar aghaidh a ghlacadh. Caithfidh Bee-Bot céim siar a ghlacadh. Caithfidh Bee-Bot ______ céimeanna a ghlacadh.

***** Baineadh úsáid as an amhrán seo le linn an cheachta Gaeilge agus beidh sé úsáideach agus na páistí á socrú ag tús an cheachta agus iad ag aimsiú a spás ar an urlár.

Amhrán Teidí beag álainn

Teidí beag álainn, teidí beag buí,
Thit sé sa pháirc agus tá sé an-tinn
Tá sé ina leaba bheag, tá sé ina luí,
Teidí beag álainn, teidí beag buí.

Ghortaigh sé a cheann agus ghortaigh sé a shúil

Ghortaigh sé a lámh agus ghortaigh sé a ghlúin. Tá sé ina leaba bheag, tá sé ina luí, Teidí beag álainn, teidí beag buí. Tháinig an dochtúir i gcarr chun an tí. "Cá bhfuil teidí beag, teidí beag buí?" Tá sé ina leaba bheag, tá sé ina luí, Teidí beag álainn, teidí beag buí. D'fhéach sé ar a cheann agus d'fhéach sé ar a shúil, D'fhéach sé ar a lámh agus d'fhéach sé ar a ghlúin, Tá sé ina leaba bheag, tá sé ina luí, Teidí beag álainn, teidí beag buí.
Áiseanna Bee-Bot, luaschartaí, <u>learscáil úrláire, snáithaid/rialóir.</u>
Cur chuige *Tá na páistí i ngrúpa faoi leith. Nuair a bhíonn an ceamara socraithe tugtar cuireadh don ghrúpa chuig an áit súgartha. Meabhraítear do gach páiste eile fanacht ina áit súgartha féin. ** Is í an Ghaeilge meán teagaisc an stáisiúin súgartha seo. Cinntigh go gcuirtear i gcuimhne do pháistí i rith an tseisiúin go labhraíonn siad le Bee-Bot i nGaeilge. **Tréimhse réamhcumarsáide** Agus na páistí ag bogadh go dtí an limistéar súgartha Bee-Bot don seisiúin cinntigh le do thoil go bhfuil an ceamara socraithe san áit cheart agus é ag taifeadadh. Tabhair cuireadh do na páistí teacht chuig an spás agus iarr orthu spota a aimsiú ar an urlár thart ar an mata urláir. B'fhéidir go spreagfá na páistí le Teidí beag álainn a chanadh agus iad ag bogadh isteach sa spás. Ba chóir go mbeadh na páistí eolach ar an amhrán seo óna gceacht Gaeilge. Taispeáin na luascártaí do na páistí. Iarr na páistí an foclóir nua a aithint agus a ainmniú. Cuir na luaschártaí isteach sa mata urláir. Athbhreithnigh na pictiúir arís agus arís eile leis na páistí ag úsáid glao agus freagairt.

Cuir Bee-Bot in aithne do na páistí. Tabhair breac-chuntas do na páistí go gcuideoidh Bee-Bot leis na páistí an scéal a insint faoi Theidí ag dul go dtí an pháirc agus é a bhogadh ó phictiúr go pictiúr eile ar an mata. **Tréimhse chumarsáide** Taispeáin conas Bee-Bot a úsáid tríd an gcéad chuid den scéal a insint agus Bee-Bot a sheoladh chuig an láthair seo. Lean ar aghaidh ag léiriú conas Bee-Bot a úsáid ag úsáid treo theanga agus céimeanna comhairimh. Is éard atá sa teanga seo ná athbhreithniú ó na gníomhaíochtaí neamhphlugáilte. Nuair a bhíonn roinnt taispeántais breathnaithe ag na páistí iarr orthu cabhrú leat Bee-Bot a aistriú go dtí an chéad áit eile. Cinntigh go bhfuil tuiscint shoiléir acu ar conas an tasc a chríochnú le Bee-Bot. Tabhair uimhir do gach páiste sa ghrúpa. Leanfaidh na páistí an patrún uimhreach seo agus iad ag bogadh Bee-Bot ar a seal ar feadh an scéil. Suigh agus breathnaigh ar na páistí agus an chéad bhall den ghrúpa ag glacadh a seal. Tabhair roinnt ama do na páistí mar ghrúpa chun leanúint ar aghaidh leis an ngníomhaíocht. Fill ar an ngrúpa gach cúpla nóiméad lena chinntiú go bhfanann siad ar an tasc. **Tréimhse iarchumarsáide** Return the group once the play session is drawing a close. Revise the story with the children and ask them what directions Bee-Bot goes in. Consistently remind the children of their Irish vocabulary. Finally, ask the children for feedback on the activity, what the enjoyed and what they would like to change for the following week.
Conas a léiríonn páistí a gcuid foghlama
Tá na páistí ag cur aithne ar Bee-Bot agus ar theanga na gníomhaíochta. Táthar ag súil le húsáid ghinearálta anseo seachas líofacht.

*GC1: Ok, you tell GC2 what to do.
*GC4: Eh, go there.
*GC4: 0[% Pointing to doctor picture].
*GC1: Eh, that's a very long way.
*GC1: So maybe GC4 maybe he could go to no wait maybe he could go to he could go siar cas this way to the súil and then here and then there?
%sct: $MED: MKO: CHI
*GC1: Yeah, ok, no, so.
*GC1: No, no, it's GC2 go.
*GC1: GC2, do you want to take your go?
%sct: $MED: MKO: CHI
%sct: $SCA: CHI
*GC1: So, like press x.
%sct: $SCA: CHI
*GC2: 0[% follows instructions].
%comp: $ALG: BOT
*GC1: And then press that button press that button.
%sct: $SCA: CHI
%sct: $SCA: BOT
*GC2: 0[% follows instructions].
*GC1: And then press that button.
%sct: $SCA: CHI
*GC2: 0[% follows instructions].
*GC1: And then press the front button that one.
%sct: $SCA: CHI
%sct: $SCA: BOT
*GC2: 0[% follows instructions].
*GC1: And then press ar aghaidh again.
%sct: $SCA: CHI
*GC2: 0[% follows instructions].
*GC1: And then press ar aghaidh.
%sct: $SCA: CHI
*GC2: 0[% follows instructions].
*GC1: And then hit the go button.
%sct: $SCA: CHI
*GC3: You done it.

Appendix N Sample transcript orange group

*OC4: I'm going to put mine in piles, and if I have too many, you can take some of mine.
*OC2: I'm going going to put mine in piles too, and you can take whatever one you want when I'm finished putting them out.
*OC2: Take them.
*OC2: Trí muicín.
*OC2: Trí muicín.
*OC4: I want my trí muicín.
*OC2: Hey, you have pota uisce te and I have a no pota uisce te.
*OC4: Then take one.
*OC2: Pota uisce te.
*OC4: No, no, not all of them.
*OC4: Only a few pota uisce te.
*OC2: I have four mac tíres.
*OC2: Now, which one do you want to take?
*OC2: Do you have any of these?
*OC2: Ok, let's go.
*OC2: They're for you.
*OC4: I only want two of these things, so they're for you.
*OC4: Two more.
*OC2: Pota uisce te.
*OC1: Salach.
*OC2: Why is OC3 be salach?
*OC3: I'm not salach.
*OC4: OC3 salach.
*OC3: I'm not salach.
*OC1: No, you're not salach it's éidí salach.

Appendix O Sample script Orange Group Day 3

*TEA: Where does he end up?
*CH5: Pota uisce te.
%comp:ABS: LANG
*TEA: Ar fheabhas.
*TEA: Cur Bee-Bot go dtí an pota uisce te.
*CH5: 0[% presses x].
%comp:ALG: BOT
*CH2: Pota uisce te.
%sct: SCA: CHI
*TEA: Taispeáin dom pota uisce te OC3?
*CH3: Eh, that one?
*TEA: Yeah, so Mia, can you go siar siar siar.
%act: Pointing out steps
%sct: SCA: TEA
*CH5: 0[% presses backwards, backwards, backwards].
*CH5: Mia uses her finger to count over and back.
%comp:DEC: BOT
%comp:ALG: BOT
*CH2: You can go siar and ar aghaidh.
%sct: SCA: CHI
%comp:ALG: LANG
*TEA: And press go and see where that gets you.
*TEA: We can do it in small parts.
%sct: SCA: TEA
*CH5: 0[% presses go].
%comp:ALG: BOT
*BEE: Bee-Bot lands short.
*TEA: Ok, now what do you need to do, Mia?
*TEA: You need to cas, don't you?
%sct: SCA: TEA
*CH1: Cas.
*TEA: Cas and ar aghaidh.
*TEA: So brú x.
*CH5: 0[% presses x].
%comp:ALG: BOT
*TEA: Now cas.
%act: pointing to right turn.
*CH5: Mia talking incomprehensibly.
*CH2: Cas timpeall.
%sct: SCA: CHI
*TEA: Cas timpeall yeah.
*CH5: 0[% presses siar].
%comp:ALG: BOT
*TEA: No, you don't need to go siar.
*TEA: Brú x arís.
%act: Leans in to help.
*TEA: So, look, we get Bee-Bot to turn and then go ar aghaidh.
%act: Pointing to the buttons.
*TEA: So brú x yeah and then cas yeah and then ar aghaidh.
*CH5: 0[% presses x, right, forward].
%comp:ALG: BOT
*TEA: Yay agus anois tá na trí muicín sásta.

Appendix P Language output: orange group sample

Social, target and functional language CH2 highest increase over 5 days

Irish used		Social and Target	Functional	Total social/ target	Total functional	Total overall
Day 1	CH1	Carr, ceann is his head		2		2
	CH2	I don't really have a leaba, Now I have two leabas, leaba, ceann, carr		5		5
	CH3	Leaba, carr, páirc, the páirc	Ar aghaidh, ar aghaidh, ar aghaidh, ar aghaidh, ar aghaidh, ar aghaidh and ar dheis	4	8	12
	CH4	Ceann, bindealán, carr		3		3
	CH5	Leaba, ceann, where's the ceann, I said ceann		4		4
Day 2	CH1	Ceapaire. The teach brice is there		3		3
	CH2	Is maith liom uisce, mac tíre, seacláid, mac tíre		7		7
	CH3	Tá, Is maith liom ceapaire, yeah I love uachtar reoite, seacláid, teach brice. Uisce ok.	go siar	10	2	12
	CH4	Muicín, is maith liom uisce		5		5
	CH5	Uisce,níl, adhmad		3		3
Day 3	CH1	salach, No you're not salach its éidí salach, éidí salach, adhmad		7		7
	CH2	Tá sé, eh mac tíre, fadó fadó, fadó fadó, bhí trí muicín ann, trí muicín, trí muicín,pota uisce te, I have four mac tíres, pota uisce te, why is OC3 be salach?, yeah éasca,its éasca, pota uisce te	you can go siar and ar aghaidh, cas timpeall	26	5	31
	CH3	mac tíre, ní, ceapaire,I'm not salach, I'm not salach, brice		6		6
	CH4	trí muicín, OC3 salach, teach adhmad, mac tíre, grána is really bad really really bad		7		7
	CH5	Em teach tuí, mac tíre, pota uisce te		6		6
Day 4	CH1	not present				
	CH2	trí muicín, carr, we can fill them in for a scéal, gorm, seacláid agus vanilla, yeah because all the trí muicín fell out, he's already on cáca, cas timpeall, d'ith gach duine milseáin,	siar siar siar siar siar everytime go siar and siar, go siar	15	10	25
	CH3	an duine an duine, seacláid and cáca, bindealán, what's gach sórt? I think the carr is going to go to the milseáin shop and then, trí muicín, aon rud eile, níl, ar aghaidh, I can do the cáca, and milseáin		19		19
	CH4	Present - no utterances				
	CH5	uachtar reoite, oráiste is maith liom oráiste		6		6
Day 5	CH1	Teidí beag, cáca, seacláid, mac tíre		5		5
	CH2	Teidí beag álainn teidí beag buí thit sé sa pháirc agus tá sé an tinn, teidí beag teidí beag teidí beag, I have two anseo, carr, carr agus uachtar reoite, mac tíre, siúcra, uachtar reoite reoite reoite uachtar reoite reoite, milseáin.	siar, ar aghaidh, ar aghaidh	34	3	37

	CH3	I have bricí, mac tíre, I think carr and then,mac tíre, uachtar reoite, and then he had a ciseán picnic, and then he had some sú oráiste, oh where siúcra, sú oráiste sa chiseán	siar, siar and then stop, ar aghaidh	12	3	15
	CH4	I think the buachaill and the mac tíre should be friends and they're going into their house, and they are going to have this, then they're going to go back into their carr and then get some sú oráiste and then they're going to go for a picnic, and then they're going to have uachtar reoirte and then this		6		6
	CH5	I have sú oráiste, and cáca,what is siúcra, uachtar reoite there it is		4		4
				199	31	230

Appendix Q Language output: green group sample

Social, target and functional language

Irish used		Social and target	Functional language	Total social and target	Total functional	Total
Day 1	CH1:	dochtúir, carr, a haon a dó a trí a ceathair, sea, carr	Siar,So that's one two press siar siar siar,téigh,ar aghaidh ar aghaidh again no again and then téigh,ar chlé,ar aghaidh ar aghaidh ar aghaidh, So maybe Rebecca maybe he could go to no wait maybe he could go siar cas this way to the súil and then here and then there, And then press ar aghaidh again, And then press ar aghaidh, ok so I'll go siar siar then cas ar chlé and then ar aghaidh and ar aghaidh, So, you wanna go ar aghaidh ar chlé,	8	23	31
	CH2:			0	0	0
	CH3:	súil, gorm, a dó, Tá an súil	press x and then press ar aghaidh an then ar aghaidh two ar aghaidh three ar aghaidh four,ar aghaidh,ar aghaidh,	6	6	12
	CH4:			0	0	0
	CH5:	Teidí	Siar,	1		1
	CH6:					0
Day 2	CH1:	milseáin, ok you go to ceapaire,bindealán, you were still going to uachtar reoite	siar siar go siar or maybe go that way, ar aghaidh again,ar aghaidh again,ar aghaidh,ar aghaidh,	4	7	11
	CH2:			0	0	0
	CH3:	dochtúir, ag ithe, leaba		4	0	4
	CH4:	bindealán		1	0	1
	CH5:	Lámh, what's lámh	ar aghaidh, ar aghaidh,	2	2	4
	CH6:	ceapaire, uisce, seacláid, leaba, is maith liom uachtar reoite, he go to páirc, he's playing on the páirc	ar aghaidh,	10	1	11
Day 3	CH1:	em so can you ag ól, eh ag ól I said, you're going to ag ól, ag ól is here, there is a ceapaire, ag úll, there is ag úll, ag ól, sú oráiste, you go to sú oráiste Mel, he's going to the sú oráiste, ceapaire	Téigh téigh téigh, ar aghaidh,	19	4	23
	CH2:					

	CH3:	Conas atá tú?, pota uisce te, pota uisce te, so you go ar aghaidh a h-aon a dó a trí, there's not ag ól and some pictures are not here, to the ceapaire, to the pota uisce te, pota uisce te, maith thú	so you go ar aghaidh a h-aon a dó a trí	23	4	27
	CH4:	úll, ag úll		3		3
	CH5:	see there's ag úll		2		2
	CH6:	uachtar reoite, is maith liom uachtar reoite, ceapaire, and the picture where's ceapaire, ag ól		9		9
Day 4	CH1:	I have a ceapaire for lunch, uisce, eh fuar		3		3
	CH2:					0
	CH3:	pota uisce te, mac tíre, tá sí ag ithe lón, trí muicín, adhmad, teach adhmad, adhmad, mac tíre, mac tíre	and clé, and ar aghaidh.	17	2	19
	CH4:	trí muicín, tíre, trí muicíns with the house, trí muicíns are over here, ar aghaidh, ar aghaidh	Ar aghaidh, ar aghaidh,	9		9
	CH5:	ceapaire, is maith liom ceapaire, isteach pota uisce te		9		9
	CH6:	not present				
Day 5	CH1:	siúcra, eh bindealán, bindealán, ar súil, teidí bocht		7		7
	CH2:	súil		1		1
	CH3:	siúcra, I'm going to get bindealán, I would like the siúcra, and the bindealán cause we need a bindealán, tá sé dochtúir, tá sé ina leaba, ocras, siúcra, so the teach tuí could be their house, glas	Ar aghaidh,	17	1	18
	CH4:	leaba and dochtúir, I don't like siúcra on its own, páirc, Beebot agus teidí sa pháirc, Beebot agus teidí sa pháirc		12		12
	CH5:	teidí beag álainn, tuí, páirc, bindealán		6		6
	CH6:	páirc, is maith liom páirc, dochtúir, now teidí bocht, you click on teidí bocht	Ar aghaidh again ar aghaidh, Cas, Ar aghaidh again	10	4	14
				183	54	237

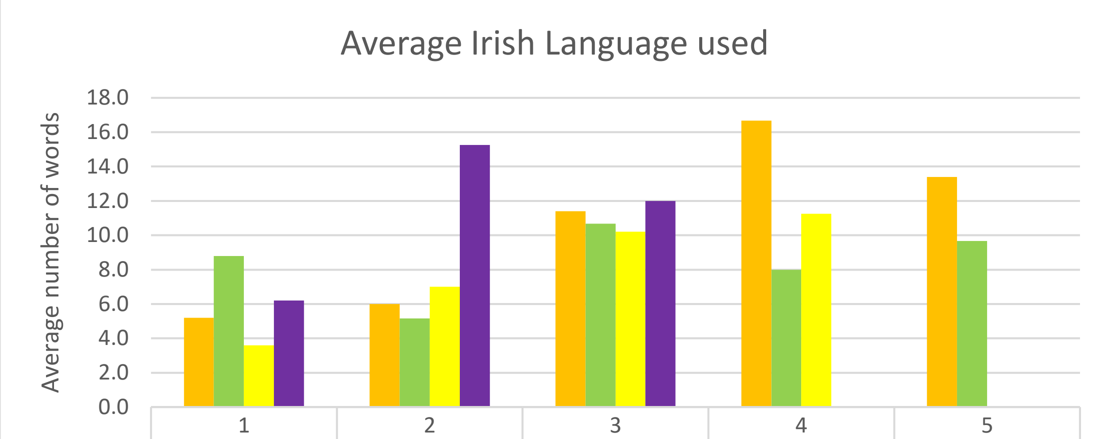
Appendix R Data analysis scaffolding

Scaffolding	Orange	Green	Yellow	Purple
Day 1	CH3: 8 SCA: CHI CH5: 1 SCA: CHI	CH1:5 SCA: CHI CH3 2 SCA: CHI	CH1: 4 SCA: CHI CH5: 2 SCA: CHI	CH3: 1 SCA: CHI CH4: 2 SCA: CHI
Day 2	CH2: 1 SCA: CHI CH3: 3 SCA: CHI	CH1: 1 SCA: BOT CH1: 5 SCA: CHI CH5: 3 SCA: CHI CH6: 1 SCA: BOT CH6: 1 SCA: CHI	CH1: 1 SCA: CHI CH4: 1 SCA: CHI CH6: 5 SCA: CHI	CH1: 9 SCA: CHI CH3: 1 SCA: CHI CH5: 3 SCA: CHI
Day 3	CH2: 3 SCA: CHI	CH1: 1 SCA: BOT CH1: 2 SCA: CHI CH2: 2 SCA: BOT CH2: 4 SCA: CHI CH3: 2 SCA: CHI	CH1: 4 SCA: CHI CH4: 1 SCA: CHI CH5: 2 SCA: CHI	
Day 4	CH2: 4 SCA: CHI CH3: 2 SCA: CHI CH5: 1 SCA: CHI	CH2: 1 SCA: CHI CH3: 2 SCA: CHI CH4: 1 SCA: CHI	CH1: 1 SCA: CHI	
Day 5	CH2: 3 SCA: CHI CH3: 7 SCA: CHI CH5: 3 SCA: CHI	CH1: 1 SCA: CHI CH3: 1 SCA: CHI CH6: 2 SCA: CHI		

Appendix S Sociocultural theory constructs: Coding sample

Sociocultural theory constructs : Coding sample				
Mediation (MKO, INTE, REG, PRI)	Orange	Green	Yellow	Purple
Day 1	CH1: 2 $MED: MKO: CHI CH3: 1 $MED: MKO: CHI	CH1: 2 $MED: MKO: TEA CH1: 1 $MED: INTE: CHI CH1: 3 $MED: MKO: CHI CH3: 1 $MED: INTE: CHI CH3: 1 $MED: MKO: CHI	CH1: 2 $MED: INTE: CHI CH1: 1 $MED: MKO: CHI CH4: 1 $MED: MKO: CHI	CH1: 2 $MED: INTE: CHI CH3: 2 $MED: INTE: CHI CH4: 2 $MED: INTE: CHI

Appendix T Average Irish language used (Social/target and functional language)



	1	2	3	4	5
Orange	5.2	6.0	11.4	16.7	13.4
Green	8.8	5.2	10.7	8.0	9.7
Yellow	3.6	7.0	10.2	11.3	
Purple	6.2	15.3	12.0		

Appendix U Orange group total language output over 5 days

Orange group		Total	Irish
Day 1	Ok.	966	389
	You guys already had a turn using Bee-Bot and we all had a turn yesterday.		
	How many do we have one two three a haon a dó a trí a ceathair a cúig.		
	So, we need a haon a dó a trí a ceathair a cúig agus a cheann dom féin.		
	Ok can you all just wiggle back a little bit from the mat.		
	Ar fheabhas because we need a little bit of space because we need our page as well, we need our leathanach with us.		
	Ok Nathaniel so seo do leathanach.		
	Tommaso seo do leathanach.		
	So, remember what we did yesterday with our leathanach.		
	Yeah so, we are just going to do that while you are waiting for your turn.		
	AJ, will you give some of them to Mia agus Nathaniel.		
	Ok so so you have loads of pictiúir don't you?		
	And just rachaimid siar ar na pictiúir cad é seo? 30		
	Buachaillí agus cailíní AJ, Mia, Róisín, Nathaniel agus Tommaso cad é seo?		
	Ar fheabhas cad é seo?		
	Tá Beebot agam tá Beebot anseo.		
	Cad é seo?		
	Ceann ach tá Beebot ag?		
	Tá Beebot ag caoineadh.		
	Cad é seo?		
	Teidí bocht.		
	Tommaso agus Nathaniel you have got try these as well.		
	Cad é seo?		
	Leaba ar fheabhas AJ.		
	Cad é seo?		
	Agus an ceann seo?		
	Agus é seo?		
	Agus?		
	Agus an ceann deireanach?		
	Ar fheabhas.		
	Ok so tá mise chun Beebot a chur ar an cearnóg glas.		
	So tá anseo tá Beebot ag dul isteach sa charr.		
	Róisín chur Beebot ag dul isteach sa charr?		
	Brú x ar dtús.		
	Ok so anois tá Beebot sa charr.		
	Ok so gach éinne cur do mhéar ar an charr?		

	Chur do mhéar ar an charr Róisín.		
	Anois tá Beebot ag dul isteach sa leaba so get a pictiúr of leaba and out the leaba here.		
	So, look.		
	You don't have a leaba.		
	So anois guys féach anseo tá Beebot sa charr agus tá sé ag dul isteach go dtí an leaba.		
	That's ok don't worry.		
	Nathaniel a chuirfidh tusa Beebot isteach sa leaba.		
	Chuir Beebot sa leaba.		
	Ah brú x ar dtús.		
	Ok you have brúigh ar dheis ar dheis so cad faoi ar dheis amháin casadh amháin.		
	Brú x ansin.		
	Agus?		
	Iontach agus cad a déanann tú anois?		
	Maith thú.		
	Brúigh go.		
	brúigh téigh.		
	Iontach anois cá bhfuil Beebot.		
	Cá bhfuil Beebot?		
	Tommaso cá bhfuil Beebot?		
	Tá Beebot sa.		
	Tá sé sa leaba.		
	Cá bhfuil an leaba anseo?		
	Faigh an pictiúr don leaba.		
	Cá bhfuil an leaba?		
	Mia cá bhfuil an leaba?		
	So cas an leathanach AJ.		
	Cas an leathanach your leathanach.		
	Cas an leathanach and get the leaba.		
	Yeah AJ get the leaba here anseo.		
	Ok is maith le Beebot dul go dtí an pháirc.		
	So tá Beebot ag dul go dtí an pháirc.		
	Faigh an pictiúr ag dul go dtí an pháirc.		
	So anois tá Beebot sa leaba ach tá sé ag dul go dtí an pháirc.		
	AJ an chuirfidh tú Beebot go dtí an pháirc le do thoil.		
	Aahhhh.		
	Now so cas Beebot timpeall ar dtús.		
	So brú x oh yeah you can go siar.		
	Oh no lig dó.		
	Ok AJ an bhfuil Beebot sa pháirc?		
	Níl Beebot sa pháirc.		
	Ah fág é cá bhfuil Beebot?		

	Tá Beebot ar an talamh.		
	Cá bhfuil Beebot ar an talamh ok.		
	Ok fan soicind AJ.		
	an chuirfidh tú Beebot go dtí an pháirc.		
	ba mhaith le Beebot dul go dtí an pháirc.		
	Níl sé briste.		
	AJ déan é uair amháin eile.		
	brú x ar dtús.		
	So, you are going to ar aghaidh ar aghaidh.		
	He would just do all the things you asked him to do the last time.		
	Maith fear AJ.		
	Beagnach ann AJ brú x uair amháin eile.		
	Ok buachaillí agus cailíní an uair seo I want you to give each other instructions is that ok?		
	So, X you are going to tell Y where he needs to go.		
	X you tell Y, Y tell X.		
	Róisín tell AJ and AJ tell Mia.		
	So, Mia you tell Nathaniel now so tell X.		
	You can try use as much of your Gaeilge as you can.		
	Mia can you tell Nathaniel where he needs to get Beebot.		
	Say the word and Nathaniel will find the picture you don’t need to point to the picture.		
	Ceann ok X.		
	Gortaigh Beebot a ceann.		
	Nathaniel did you get it?		
	Ok.		
	AJ its Nathaniel’s turn.		
	That’s Beebot ag caoineadh that's not his ceann that's ag caoineadh.		
	Cá bhfuil ceann Beebot.		
	Yeah so seo ceann Beebot seo Beebot ag caoineadh.		
	Nathaniel you give Tommaso an instruction.		
	Ok excellent Tommaso you ask Róisín.		
	AJ!		
	Beagnach ann cur céim amháin eile isteach.		
	Agus ar ar aghaidh 32		
	Where do you want Beebot to go?		
	You could go siar.		
	And then cas.		
	Yeah.		
	And then you'll need to go ar aghaidh.		
	Yeah agus brúigh téigh.		
	Buachaillí agus cailíní what did you think of Beebot this time?		

	What did you think of it?		
	Was it easy or difficult?		
	Nathaniel what do you think?		
	Róisín Nathaniel will speak first and then you will get a chance to speak.		
	Was it difficult?		
	What did you like about using Beebot?		
	Róisín what about you?		
	Ok I know but time is up because it's really close to lunchtime ok.		
	You'll get a chance another day, but you did get a chance at pressing the buttons and AJ had a turn to press the buttons.		
	I think everyone had at least one chance at pressing the buttons.		
	Mia did you like using Beebot?		
	Anyone anything to add?		
	Was it easy or difficult?		
	AJ what did you think?		
	Do you know why it went the wrong way?		
	What happened that it went the wrong way?		
	And we just fix and try, again don't we?		
	Ok buachaillí agus cailíní lets glanadh suas. 15		
Day 2	Ok can anybody remember anything on this I know some of you were off sick you weren't ar scoil and some of us were and we know the scéal.	1222	619
	Does anybody remember anything on the mat?		
	Mia can you tell me anything on the mat?		
	Uisce ar fheabhas.		
	An maith leat uisce?		
	An maith leat uisce?		
	Ar fheabhas Tommaso is maith liom uisce.		
	Róisín cad eile a fheiceann tusa ar an mata?		
	Na trí muicín.		
	Let's comhairigh iad.		
	Na trí muicín.		
	An maith leat na trí muicín?		
	Ar fheabhas. 42		
	Nathaniel?		
	Ceapaire, cá bhfuil an ceapaire?		
	Ca bhfuil sé?		
	Cá bhfuil an ceapaire?		
	Seo an ceapaire.		
	An maith leat ceapaire?		
	What do you put in your ceapaire AJ?		
	Oh, cáis mmmm.		

	Róisín what do you like to put in the ceapaire?		
	Ar fheabhas.		
	Nathaniel cad a chuireann tusa isteach sa cheapaire? 31		
	Peanut butter mmm.		
	Cad fútsa Tommaso?		
	Liamhás agus cáis mmm.		
	Agus Mia cad a chuireann tusa isteach sa cheapaire?		
	Liamhás is maith liom liamhás.		
	What else can you see on the mat?		
	Tommaso can you see anything else?		
	Cad eile a fheiceann tusa?		
	Ar fheabhas.		
	Cá bhfuil an mac tíre? 30		
	Cá bhfuil sé?		
	Tá sé ansin.		
	An maith leat an mac tíre?		
	Ní maith liom.		
	Maith cailín Mia.		
	An bhfuil an mac tíre deas do na trí muicín?		
	Bhfuil sé deas do na trí muicín?		
	Níl sé deas nach séideann sé an teach? 42		
	What did you say Mia?		
	An teach brice.		
	What about the teach tuí.		
	Does anybody like the teach tuí?		
	And the teach adhmad.		
	Ok let's have a little look.		
	Teach brice.		
	Ag ithe.		
	Ciseán.		
	Do you have a ciseán?		
	Do you ever go on a picnic and bring a ciseán with you?		
	Well the ciseán is holding the food its holding the bia.		
	So, you have your own ciseán for the picnic?		
	Excellent.		
	Ceapaire.		
	Cad é seo?		
	Uachtar reoite.		
	Do you like uachtar reoite?		
	Cad é an flavour is fearr leat?		
	Seacláid ar fheabhas agus Mia céard fútsa?		
	Blueberry uachtar reoite.		
	Agus Róisín cad fútsa? 44		

	Oh, wow vanilla, seacláid agus sú talún uachtar reoite mmm.		
	Tommaso cén uachtar reoite is fearr leat?		
	Vanilla agus an seacláid flake.		
	Yeah is maith liom flake agus sprinkles chomh maith.		
	Sú oráiste.		
	An maith leat sú oráiste.		
	Ní maith liom sú oráiste.		
	Ní maith liom é.35		
	Oh.		
	Tart.		
	Tart is when you want a deoch you are ag iarraidh deoch.		
	Na trí muicín.		
	Ocras.		
	Ocras is when you really want your lón.		
	Agus teach adhmad.		
	Teach tuí.		
	Cad é seo?		
	Cad é seo?		
	Pota.		
	Uisce.		
	Te.		
	Ar fheabhas.		
	Ok let's have a little look quickly and then we will tell the story in the correct order.		
	Actually, no we will tell the story in the correct order straight, away will we?		
	Can you remember what happened at the start?		
	Cé a chonaiceamar ar dtús? 33		
	Yeah.		
	Chonaiceamar na trí muicín.		
	Bhí trí muicín ann.		
	Nathaniel cur Beebot go dtí na trí muicín.		
	Nathaniel, I like how you are using your finger to count on the cearnógs.		
	Aw beagnach ann.		
	Aw iontach.		
	AJ go raibh maith agat.		
	So bhí trí muicín ann agus thóg siad teach.		
	Thóg an chéad muicín teach tuí.		
	Mia cur Beebot go dtí an teach tuí.		
	So brú x ar dtús.		
	Iontach so thóg an chéad mhuicín teach tuí.		
	Ach céard a tharla don teach?		
	Cé a tháinig go dtí an teach?		

	Tháinig an.		
	Mac tíre gránna. 70		
	Do you remember?		
	So Róisín cur Beebot go dtí an mac tíre.		
	Nathaniel you need to suí síos anseo.		
	Yay iontach.		
	Ok ag tús an scéal bhí trí muicín ann.		
	Thóg an chéad muicín teach tuí ach tháinig and mac tíre agus cad a rinne an mac tíre? 35		
	Shéid sé agus shéid sé agus leag sé síos an teach.		
	Agus rith an muicín go dtí cén teach eile?		
	Mia an teach.		
	Mia an gcuirfidh tusa Beebot no Tommaso.		
	Sorry Mia you had a turn and you will have a turn again.		
	Tommaso cur Beebot go dtí an teach adhmad.		
	Its fada isn't it.		
	So brú x ar dtús.		
	And then you are maybe going to go siar are you.35		
	When are we finished Beebot?		
	Cúpla nóiméad and then you will have time for Aistear.		
	Im going to finish the scéal with you and then you are going to have a turn by yourself.		
	No, you will get another turn.		
	Tommaso what happened to Beebot?		
	Did you forget to turn Beebot around?		
	Im going to put Beebot here.		
	So cá bhfuil Beebot ag dul?		
	Tá sé ag dul go dtí an teach adhmad.		
	So chuir Beebot go dtí an teach adhmad.		
	Ok come on Tommaso.		
	So brú x ar dtús.		
	Ok so anois tá na muicín sa teach adhmad.		
	Ach cé a tháinig chuig an teach?		
	Tháinig an?		
	An mac tíre agus cad a deirinn an mac tíre? 48		
	Cad a déanann sé?		
	Do you remember?		
	An cuimhin leat?		
	AJ.		
	Cur Beebot go dtí an mac tíre.		
	Nathaniel you need to suí suas if you are going to be having a turn in a few moments.		
	So, you have to go siar siar.		
	And then you have to go ar aghaidh.		

	Did you forget to press ar aghaidh at the end?		
	So, he's going to stop anseo isn't he?		
	So, do you remember that shéid an mac tíre an teach síos.		
	Uh oh, Mia will you críochnaigh é sin do AJ.		
	He has to go to the mac tíre.		
	So brú x.		
	Ok where does the mac tíre go next or where does the muicín go next and where does the mac tíre go?		
	The teach.		
	Teach brice. 41		
	Nathaniel can you get Beebot to the teach brice.		
	Tá na muicín ar fad sa teach brice.		
	You need to go siar one more.		
	And now cas.		
	I don't know let's see.		
	Oh, I don't know but its siar siar siar cas and ar aghaidh.		
	Can you do the ar aghaidh bit.		
	So, you are going to be going ar aghaidh yeah.		
	Ok Nathaniel suí síos and let's see if Beebot gets it.		
	Aw iontach Nathaniel nearly got it go arís.		
	So brú x ar dtús.		
	So anois tá na trí muicín sa teach brice.		
	Tagann an mac tíre but is the mac tíre able to leag síos an teach? 43		
	So, cad a déanann sé?		
	Téann sé suas an simléar agus tagann sé síos an simléar and what does he go into when he goes síos an simléar?		
	Ar fheabhas Tommaso cur Beebot go dtí an pota uisce te.		
	Can you do that?		
	Try put Beebot to the pota uisce te.		
	Its te isn't it. 31		
	Go ar chlé arís.		
	You've got him ar aghaidh and go ar chlé arís oh no wait sorry go ar aghaidh.		
	Press go, and we will see where he gets to.		
	AJ you do the next bit.		
	So táimid ag iarraidh an pota uisce te a fháil a bhaint amach.		
	X ar dtús.		
	Beagnach Mia can you get Beebot to the pota uisce te? 24		
	Its ok AJ let Beebot go.		
	Hmmmm.		
	Pioc suas Beebot AJ agus cur Beebot ar na trí muicín.		
	Cur Beebot ar na trí muicín.		

	No pioc suas é pioc suas Beebot agus cur Beebot ar na trí muicín.		
	Ok Róisín tá Beebot ag iarraidh dul go dtí an pota uisce te. 35		
Day 3	Ok what can you see ar an mata?	922	454
	Cad a fheiceann sibh ar an mata?		
	Mmmmm what's the other word for wolf that you know?		
	Mac tíre ar fheabhas.		
	An maith leat an mac tíre?		
	Ní maith liom mac tíre.		
	Tá an mac tíre gránna.		
	Tá sé lofa. 30		
	AJ what else can you see sa phictiúr nó an?		
	Ceapaire an maith leat ceapaire Tommaso?		
	Yeah is maith liom ceapaire.		
	What do you put in ceapaire Róisín?		
	An itheann tú ceapaire?		
	Cad a chuireann tú isteach ann?		
	Mia can you see anything can you name anything on the mat?		
	Teach tuí ar fheabhas.		
	Cé a bhí ina chónaí sa teach tuí.		
	Mac tíre nó muicín?		
	Ok Róisín an fheiceann tusa aon rud ar an mata? 48		
	Can you name anything?		
	Na trí muicín.		
	Féach anseo a haon a dó a trí.		
	Na trí muicín.		
	Ar fheabhas Tommaso can you name anything here?		
	Cá bhfuil an mac tíre?		
	Cá bhfuil sé?		
	Mac tíre?		
	Mac tíre?		
	Cá bhfuil sé?		
	Ar fheabhas. 30		
	Ok let's name everything together.		
	You ready Nathaniel?		
	Na trí muicín.		
	Can you all say it?		
	Na trí muicín.		
	Ag ithe.		
	Ciseán.		
	C.		
	Ceapaire ar fheabhas AJ.		
	Uachtar reoite.		

	Sú oráiste.		
	Mac tíre.		
	Teach adhmad.		
	I can only hear Tommaso and AJ and they're doing a super job lets if everyone else can join in.		
	Uisce.		
	Pota uisce te.		
	Teach brice.		
	Ag ól.		
	Teach tuí.		
	Ar fheabhas.		
	So, we are going to tell the story of na trí muicín. 34		
	Ok can you remember the story?		
	How does it start?		
	Yeah so bhí trí muicín ann so everybody get the pictiúr trí muicín.		
	Oh, wow saying it again.		
	Ar fheabhas Tommaso cur Beebot go dtí na trí muicín.		
	Yeah déan é.		
	So brú x ar dtús.		
	Ok Nathaniel bhí trí muicín agus thóg an chéad muicín teach tuí.		
	Cá bhfuil an teach tuí?		
	Taispeáin dom teach tuí?		
	Ar fheabhas Nathaniel an cuirfidh tusa Beebot go dtí an teach tuí?		
	Brú x ar dtús.		
	Yeah now you have to cas.		
	and then ar aghaidh. 50		
	Brú go and see what happens.		
	Ok so did he need to cas twice or just once Nathaniel?		
	So brú x.		
	cas once yeah and then you're going to be going ar aghaidh		
	Leave him alone.		
	So, we are looking for the teach tuí cause thóg an chéad mhuicín teach tuí.		
	Ar fheabhas.		
	Cad a tharla?		
	Cé a tháinig chuig an teach?		
	Tháinig an?		
	Mia cé a tháinig chuig an teach?		
	Agus cad a dúirt an mac tíre?		
	Cad a rinne sé?		
	Agus cad a rinne sé.		

	Ar fheabhas Mia cur Beebot go dtí an mac tíre.		
	Ah ah ah you are able to do it.		
	Brú x.		
	Now you need to cas don't you?		
	Cas not ar aghaidh.		
	So Beebot is going in this direction if we cas not ar aghaidh.		
	So, did you find the mac tíre Mia? 61		
	Ok press go, and we will see where you get to and we can do it in small steps.		
	Mia leave him.		
	Ok so what could we do really small?		
	We could cas once.		
	Can you get Beebot to cas?		
	Ok even if we get that bit ar aghaidh ar aghaidh ar aghaidh.		
	Sorry guys.		
	Why is Beebot over here?		
	Ok so we wanted to Beebot to the mac tíre.		
	So leag an mac tíre síos an teach.		
	So, cad a tharla ansin?		
	Thóg an dara mac?		
	Thóg an dara muicín teach?		
	Cén sort teach Róisín?		
	Teach?		
	Ar fheabhas teach adhmad.		
	Cur Beebot go dtí an teach adhmad.		
	Ná déan dearmad x a bhrú ar tús.		
	Nearly Róisín.		
	So, we went siar when we should have went ar aghaidh.		
	So, can you get him to the teach adhmad? 50		
	Brú x ar dtús.		
	Ok anois.		
	Cé a thagann chuig an teach?		
	Or cé a tháinig chuig an teach?		
	Cé a tháinig?		
	Yeah.		
	Tháinig an mac tíre go dtí an teach.		
	Tommaso can you, AJ did you have a turn?		
	Oh sorry.		
	AJ can you put Beebot go dtí an mac tíre gránna? 33		
	Yeah.		
	Ná déan dearmad x a bhrú ar dtús.		
	No, you're right ar aghaidh.		
	Do you need to press anything else?		
	Ar fheabhas.		

	Agus cad déanann an mac tíre, shéid sé agus shéid sé agus leag sé síos an teach.		
	So, cad a dhéanann siad ansin rith na trí muicín go dtí cén teach?		
	Rith na muicín go dtí teach?		
	Brice ar fheabhas.		
	Tommaso an cuirfidh tusa Beebot go dtí teach brice? 55		
	Maith an cailín Mia.		
	Its éasca is it?		
	Ar fheabhas agus cad a déanann an mac tíre sa teach sin?		
	Téann sé suas an simléar agus téann sé síos an simléar and what happens Mia?		
	Where does he end up?		
	Ar fheabhas. 28		
	Cur Beebot go dtí an pota uisce te.		
	Taispeáin dom pota uisce te AJ?		
	Yeah so Mia can you go siar siar siar.		
	And press go and see where that gets you.		
	We can do it in small parts.		
	Ok now what do you need to do Mia?		
	You need to cas don't you?		
	Cas and ar aghaidh.		
	So brú x.		
	Now cas.		
	Cas timpeall yeah.		
	No, you don't need to go siar.		
	Brú x arís.		
	So, look we get Beebot to turn and then go ar aghaidh.		
	So brú x yeah and then cas yeah and then ar aghaidh.		
	Yay agus anois tá na trí muicín sásta. 35		
Day 4	Ok buachaillí agus cailíní we are going to make up a scéal today ok?	1306	679
	So, like the trí muicín is a scéal.		
	So, lots of different scéalta you know.		
	And then we are going to use Beebot to tell our scéal.		
	So, our scéal can be about a buachaill or a cailín.		
	What do you want the scéal to be about?		
	So, we are making this up together we are working together as a team.		
	AJ who's going to be in the scéal?		
	Or what pictiúir do you want to put in the scéal?		
	Can you remember what any of them are?		

	Cáca and milseáin.		
	Well they could be seacláid actually if they were smartie, they would be seacláid and if they were skittles, they'd be milseáin wouldn't they?		
	Can I have them?		
	So maybe there is a breithlá going on.		
	Ok Róisín can you pick a cárta for me?		
	For our scéal we've got a cáca.		
	we've milseáin we've got a unicorn.		
	Ok Róisín pioc cárta eile.		
	Cárta eile.		
	Any cárta.		
	Maybe somebody eats too much cáca and they're tinn and they have to go to the dochtúir.		
	Or maybe they need a bindealán cause thit siad.		
	Ok bindealán.		
	Ok Tommaso you pioc dhá chárta.		
	Na trí muicín agus ceann amháin eile.		
	Ok you want uachtar reoite.		
	Ok Tommaso pioc ceann amháin eile agus Mia pioc ceann amháin eile.		
	Carr ar fheabhas. 58		
	Agus Mia?		
	Oráiste ar fheabhas.		
	Ok bailigh suas na cártaí eile.		
	Bailigh suas iad.		
	Maith an cailín Róisín tá Róisín ag bailiú na cártaí.		
	No.		
	We just don't need all these cártaí.		
	Too many words and too many cártaí.		
	Go raibh maith agat AJ go raibh maith agat Róisín.		
	Go raibh míle maith agat.		
	We going to put them in for a scéal.		
	We are going to make a scéal now.		
	We are just going to make sure we can all remember the words all the		
	foclóir.		
	Unicorn.		
	Oráiste.		
	An maith leat oráiste? 42		
	Mia?		
	Carr.		
	Carr.		
	Cén dath atá ar an gcarr?		

	Cén dath?		
	Dearg?		
	Glas.		
	Buí.		
	Cén dath?		
	Gorm ar fheabhas, iontach.		
	Na trí muicín.		
	Tuí.		
	Adhmad.		
	Brice.		
	Uachtar reoite.		
	An maith leat uachtar reoite?		
	Cén sórt uachtar reoite is fearr leat?		
	Is fearr liom vanilla.		
	Cén sórt uachtar reoite is fearr leat?		
	Is fearr leat vanilla ar fheabhas.		
	Agus cad fútsa Róisín cén sórt uachtar reoite is fearr leat?		
	Is maith leat gach sórt uachtar reoite? 65		
	Fair enough.		
	Gach sórt every type.		
	Is maith liomsa uachtar reoite le seacláid agus sprinkles I ngach áit.		
	Is maith leat seacláid sa cón freisin?		
	Mise freisin.		
	Tommaso cén sórt uachtar reoite is fearr leatsa Tommaso?		
	Iontach ar fheabhas ar fad.		
	Bindealán. 32		
	Cur mé bindealán ar mo chos nuair a thit mé agus gortaigh mé mo chos bhí orm bindealán a chur air.		
	Cáca.		
	Cáca seacláid.		
	An maith leatsa cáca seacláid?		
	Agus milseáin.		
	Ar fheabhas.		
	We are going to make up a scéal with all of these things in it.		
	So, have a little think Im going to pop them in this mat and then we will make up the scéal.		
	So, can anybody think about what is going to happen in our scéal?		
	There's a píosa briste.		
	That's why I didn't want you guys to be putting them in in case it broke a little bit more.		
	Cause somebody did that one of the boys and girls did that.		
	Can you think of what's going to happen in the scéal?		

	The carr is going to go to the siopa is it? 41		
	And who is going to be ag tiomáint an charr?		
	An unicorn nó na trí muicín?		
	Ag tiomáint?		
	Who's going to be ag tiomáint?		
	Na trí muicín ag tiomáint an charr agus téann siad go dtí an siopa agus cad a cheannaíonn siad sa siopa?		
	Ceannaíonn siad?		
	Uachtar reoite.		
	Ceannaíonn siad aon rud eile?		
	An cheannaíonn siad cáca agus oráiste? 47		
	Níl ok.		
	Agus cad eile a tharlaíonn sa scéal where does the bindealán come into the scéal?		
	Why do we have a bindealán Tommaso?		
	Oh, bhí timpiste ann, timpiste pew.		
	Briseann siad a chos.		
	Thit siad ar an talamh.		
	Agus gortaigh siad a chos.		
	Oh no and then they have to go to the ospidéal don't they?		
	Thit siad amach an fhuinneog.		
	Oh no.		
	Arís agus arís agus arís.		
	Wow.		
	Gach uair arís.		
	Ok Róisín what do you think of the scéal?		
	AJ bog siar píosa beag le do thoil.		
	No, we have go leor pictiúir anseo.		
	AJ bog siar píosa beag.		
	Ar fheabhas.		
	So ar dtús bhí trí muicín ann chuaigh na trí muicín sa charr go dtí an siopa.		
	Cheannaigh siad cáca. 79		
	Cheannaigh siad milseáin.		
	Cheannaigh siad uachtar reoite agus cheannaigh siad?		
	Oráiste.		
	Chuaigh siad abhaile sa?		
	And then thit muicín amach ón charr as an charr.		
	Thit muicín amach as an charr.		
	Gortaigh sé a?		
	Cos.		
	Chuir sé bindealán air.		
	Agus d'ith sé cáca?		
	D'ith sé milseáin?		

	D’ith sé uachtar reoite?		
	Agus d’ith sé oráiste?		
	What about the unicorn though?		
	The unicorn wasn’t in our scéal.		
	Chuir on unicorn bindealán ar an muicín? 57		
	I like it.		
	Ok.		
	We ready guys?		
	You have to help me with this scéal.		
	Are you ready Mia?		
	So fadó fadó bhí trí muicín.		
	Can you find the trí muicín?		
	Oh, Mia is going to do Mia cur Beebot go dtí na trí muicín le do thoil.		
	Ar fheabhas.		
	Chuaigh na trí muicín go dtí an siopa sa charr.		
	Tommaso cur Beebot go dtí an carr.		
	Well maybe you could get Beebot to go siar siar cas and then <u>ar aghaidh</u> <u>ar aghaidh</u> <u>ar aghaidh</u>?		
	So brú x ar dtús. 43		
	You won’t.		
	Just leave it.		
	Ok so brú x ar dtús.		
	Sorry Tommaso.		
	So, watch did you cas?		
	Ok so brú x.		
	Siar.		
	Now you need to cas.		
	And now <u>ar aghaidh.</u>		
	Now you're here so you need to <u>ar aghaidh.</u>		
	<u>Ar aghaidh</u> yeah AJ has it.		
	Yeah agus arís.		
	Agus brú go.		
	Fadó fadó bhí trí muicín ann.		
	Chuaigh siad sa charr go dtí an siopa.		
	Sa siopa cheannaigh siad uachtar reoite.		
	Róisín cheannaigh siad uachtar reoite. 36		
	So, we were trying to find <u>uachtar reoite</u> Róisín can you find <u>uachtar reoite?</u>		
	Ar fheabhas.		
	So fadó fadó bhí trí muicín ann.		
	Chuaigh siad go dtí an siopa sa charr.		
	Cheannaigh siad uachtar reoite.		
	Cheannaigh siad cáca.		

	Agus cheannaigh siad oráiste.		
	Mia?		
	So, bog siar Róisín so you are not touching Beebot.		
	Ok so Mia can you get Beebot to the oráiste?		
	Ok Mia pioc suas Beebot le do lámh.		
	Look pioc suas Beebot. 39		
	Agus cur Beebot ar ais anseo.		
	Try it again.		
	So brú x ar dtús.		
	Ar aghaidh.		
	And then cas.		
	And then brú ar aghaidh.		
	and the téigh.		
	Yay.		
	Ok.		
	fadó fadó bhí trí muicín ann.		
	Chuaigh siad go dtí an siopa sa charr.		
	Cheannaigh siad uachtar reoite.		
	Cheannaigh siad cáca agus cheannaigh siad oráiste.		
	Agus na milseáin.		
	Chuaigh siad abhaile sa charr.		
	Can you get Beebot chun dul go dtí an charr? 51		
	Brú x ar dtús.		
	Yeah ar aghaidh.		
	Yeah and the ar aghaidh.		
	And the brú go.		
	Excellent.		
	Then ar an bhealach abhaile bhí timpiste ann.		
	Thit muicín ar an talamh.		
	Thit muicín ar an talamh.		
	Gortaigh sé a.		
	Gortaigh sé a chos.		
	Chuir unicorn bindealán air.		
	So Róisín an rachaidh tusa go dtí an unicorn? 39		
	No, we didn't that's ok.		
	Uh oh Róisín can you do it?		
	So, remember bhí timpiste ann gortaigh sé a chos .		
	Ok we are nearly finished.		
	So, cur an unicorn bindealán air.		
	AJ an rachaidh tusa go dtí an bindealán? 16		
	Ok and Mia is going to do the very last one for us.		
	Mia are you ready?		
	D'ith gach duine milseáin.		

	Bhí gach duine ag ithe milseáin.		
	Bhí na muicín ag ithe milseáin, bhí unicorn ag ithe milseáin.		
	Cá bhfuil na milseáin?		
	Brú x ar dtús.		
	Agus sin é sin deireadh an scéal. 34		
	Well done.		
Day 5	Ok two pictiúir le haghaidh an scéal.	770	308
	Ok have we all got some pictiúir?		
	Well everybody should have two pictiúir for me to make up a scéal?		
	Excellent.		
	Cad atá agat Nathaniel?		
	Agus.		
	Milseáin.		
	Alex are you ok?		
	What do you have Mia?		
	Sú oráiste agus cad eile.		
	Ciseán.		
	Agus cad atá agat AJ?		
	Teach brící agus.		
	Mmm.		
	Ar fheabhas cad atá agat Tommaso?		
	We just need two Tommaso ok.		
	AJ can I have that other pictiúr please.		
	Uachtar reoite agus.		
	Nathaniel can I have that please.		
	Agus Róisín cad atá agat?		
	Can I have yours?		
	A buachaill.		
	Nathaniel you can pop yours under there.		
	Show me.		
	Siúcra. 40		
	Conor you leave that in your bag and go to Aistear please.		
	So Róisín, AJ everybody needs to move a tiny little bit away from the mata.		
	Make sure you are not touching the mata.		
	AJ can you pop your pictures under there for me.		
	And Róisín can you pop yours under there anywhere.		
	No just leave them under it AJ.		
	Just leave them on the ground.		
	You want it there ok.		
	Now AJ bog do lámh le do thoil go raibh maith agat.		

	Ok.		
	That's ok.		
	Can anybody make a little bit of scéal for us?		
	Well everybody can have a look at it but AJ and decide on our scéal should be.		
	Remember to use as many of your Gaeilge words as you can.		
	Buachaill.		
	Teach brící.		
	Mac tíre.		
	Uachtar reoite.		
	So, do you think are the buachaill and the mac tíre are friends are they cairde.		
	Ok so is buachaill deas é agus níl an mac tíre.		
	Ok Róisín what do you think our scéal should be.		
	Cool.		
	Ok.		
	Will we have them as cairde?		
	Cause usual the mac tíre we make him out to be horrible but maybe he is deas?		
	Ok so can we all make sure we are not touching the mat Róisín.		
	Thank you very much.		
	Ok so lá amháin bhí mac tíre ann.		
	So, who can find mac tíre? 46		
	Róisín.		
	Who can find mac tíre?		
	Fadó fadó bhí mac tíre ann isn't that right Tommaso?		
	You like fadó fadó.		
	Róisín faigh an mac tíre.		
	It does.		
	Bhí an mac tíre cairdiúil le buachaill.		
	AJ, bhí an mac tíre cairdiúil le buachaill.		
	AJ.		
	what happened Nathaniel?		
	Did you forget to press x?		
	Ok let's go again.		
	I will brú x.		
	So bhí an mac tíre cairdiúil le buachaill.		
	Brú x ar dtús.		
	X.		
	Ok bhí an mac tíre agus an buachaill cairdiúil le chéile is cairde iad. 51		
	Bhí siad ina chónaí I dteach brice.		
	Mia bhí siad ina chónaí i dteach brice.		

	Ná déan dearmad brú x ar dtús.		
	Ok press go Mia.		
	Ok Mia he is at the teach brice isn't he?		
	That's where he is going.		
	Fadó fadó bhí mac tíre ann agus bhí buachaill ann.		
	Bhí an mac tíre agus an buachaill cairde, cairdiúil le chéile.		
	Cónaigh siad i dteach brice.		
	Lá amháin bhí siad ag dul le haghaidh picnic.		
	Chuaigh siad isteach sa charr. 62		
	Nathaniel chuaigh siad isteach sa charr.		
	Ah ná dearmad ar x.		
	Guys you are all forgetting x today what's happened.		
	You didn't forget it Róisín you're right.		
	Ok.		
	Can you get him from there to the carr?		
	Mia sit up straight and get your feet off the mat.		
	Can you get him to the carr Nathaniel?		
	X ar dtús.		
	Yeah, you're right.		
	So féach ar seo Nathaniel.		
	Beagnach ann.		
	Mia cas timpeall le do thoil.		
	Ok chuaigh siad isteach sa charr.		
	Ag an pháirc bhí picnic acu.		
	Picnic.		
	Bhí picnic acu.		
	So tá ciseán ag an mac tíre agus an buachaill le haghaidh picnic.		
	Ciseán.		
	Yeah, we need to go to the ciseán.		
	Let's go Tommaso.		
	Don't forget x ar dtús.		
	Sa chiseán bhí cáca.		
	Róisín sa chiseán bhí cáca. 61		
	Nathaniel can you move off the mat please.		
	You can move the box behind you.		
	Ok now move your mat away from the Beebot mat.		
	Thank you very much.		
	Róisín bhí cáca sa chiseán.		
	No leave it Róisín.		
	You should have gone ar aghaidh instead of siar for the second part.		
	Ok Róisín tá cáca sa chiseán get the cáca for us.		
	Ok AJ bhí siúcra sa ciseán.		

	Look siúcra.		
	Yeah sin siúcra.		
	Yeah AJ bhí siúcra sa chiseán.		
	Brú x ar dtús.		
	Excellent.		
	Mia bhí sú oráiste sa chiseán.		
	Mmmmhmmm.		
	And then ar aghaidh.		
	No no she has another ar aghaidh to do first.		
	Ok Nathaniel tá uachtar reoite sa chiseán.		
	Agus Nathaniel tá milseán sa chiseán. 40		
	Ok Nathaniel oh Tommaso sorry Nathaniel.		
	Tommaso tá milseán sa chiseán.		
	Yay.		
	Ar fheabhas guys sin é. 8		

Appendix V Teacher's Interview Thematic analysis

Quote	Code/ Annotation	Theme	
TEA: Ok the unplugged activities that we did were on a whole class level at first and we just used the to teach the vocab of ar aghaidh, cas, siar, téigh and stop. I think I did stop even though it wasn't necessary. We used I used visual aids and then put them on them whiteboard and then we were the human robots going ar aghaidh or cas, siar and I felt it was very slow to pick up vocab, like every time we went to do it like the next day, I went do it again I felt like I was starting from the beginning all the time. And then so I was a bit worried when we were doing that, I was like they're not going to get this vocab at all and then we did in small groups after modelling it as a whole class we used the unplugged A3 pages with the boxes and the visual cards to put the arrows and they used a car and they drove the car into teddy.	Activity: Struggle, Modelling	SCT:Physical Scaffolds	CT: Unplugged activities
TEA: So that was more productive, but it was definitely only still like the stronger children in the class who are mastering that and some of them were sitting there with vacant stares. They would kind get into using their English vocab but even with encouragement they weren't using their Irish vocab, so I was probably had too high expectations for the Junior Infants with their Irish vocab with the unplugged activities.	Activity, struggle, expectations	SCT: MKO	
TEA: I think initially they probably had more of the directional language than I gave them credit for. Initially they didn't have the Irish, but I wanted the Irish I just think I had too big of expectation. Because then they did the 2nd or 3rd time, we did the unplugged activity they had it in English some of them would be like what's the Irish word for?	Activity: Expectations, transition from English to Irish creating a foundation		
TEA: they would clarify anything if they were in charge be honest so that was on before Christmas yeah, they were the 2 unplugged things I did I don't I didn't do any other Beebot unplugged stuff.	SCT: MKO		
TEA: No, it's probably the amount of time I spent on it was probably enough because the second I introduced Beebot the motivation to learn and to use Beebot was much stronger than the unplugged activities.	Activity: Timeframe		
TEA: During Aistear they had free opportunity to use the unplugged stuff if they wanted to. They weren't chosen really at all I think one or two chose them the first day, but they weren't a big hit.	CT: Unplugged activity		

TEA: In comparison to at the end of the at the end of the cycle or programme that Beebot was available during Aistear and Beebot was always taken up	Activity: Motivation-sustained interest		
TEA: I know I know I don't know was it just too boring for them. They engage with most games, but it wasn't that when it was during Aistear, I understand that they love like nothing can compare to junk art for some of them like yeah there's so much choice. But when they were doing it as a whole class all doing the same unplugged activity and they still weren't motivated I don't know they must have just found it boring or maybe was too overwhelming me trying to do it as a whole class or when they were in small groups. So maybe it would have been better if it was something I had introduced with a station or a group of children first or maybe I should have included it in Aistear for 10 minutes and then they might have had a better sense of it.	CT: Unplugged activity, motivation		
TEA: So we picked the topics so that I was pre teaching the vocab for my formal and the first couple weeks and then by the time I got to the formal Irish lesson the children had the vocab and were ready to put them into shorter sentences or they were able to understand when I put into a full sentence and that made Irish lessons, <u>there was very little teaching like I had to extend all the Irish lessons from the programme from the junior infant programme because they had the vocab. And then their interests they were interested in the vocab with Beebot and then in turn they were more interested in the formal Irish lessons as well and the scéal (story) that happened on the board or the amhráin (song) or the dán (poem) or whatever we were learning all seem to become more become easier because the more vocab and it has more more motivation and they were just more interested in learning.</u>	Activity: Motivation from the activity	Language	
TEA: By the time we got to the last week when they were making up their own scéalta (stories) it was mad (surprising) to see them using the vocab from 6 weeks nearly seven weeks previously wasn't it?	Language: Recall	SCT: Internalisation	
TEA: Even though there was a lot of English being thrown into the story they were still using all their Irish vocab or even when you were telling the scéal of mac tire agus trí muicín some of them really had really long sentences and they understood, and I know it's an advantage that they are familiar with the story in English, but it was still very impressive to watch.	Language: Recall	SCT: internalisation, Teacher observation	

TEA: I liked doing the theme and it was obviously so handy for me that resources were dropped me on a weekly basis. Going forward I would definitely do something similar, but I would probably prioritise certain themes and stick at it maybe for two weeks with Beebot because otherwise they are only getting a chance to use the vocab once with Beebot and then and even to keep on top of making the resources for it to be quite honest it would be easier if I prioritised certain topics and themes.	Activity: Design of activity moving forward		
TEA: Em yeah usually my experience of teaching Irish so far is follow the programme that the school as decided upon. So, I've never had that much that big of a decision to make. And it was kind of probably brave to think that we picked scéalta for the that the Junior Infants would be making up their own stories when this is something they haven't really touched on in English. And we decided to do it in Irish. But I just thought when they were so interested and there was such progress being made with their Irish that it was better off to challenge them and see how they would get on rather than like deciding beforehand that they didn't that they wouldn't be able for it.	Activity: extension, agency, high expectations		
TEA: I think in the videos if it was like cáca I would be like an maith leat cáca and they would say is maith liom cáca. So, its showing them another way they may have come across the word cáca already.	Language: Integration		
TEA: And then around the room the rest of the children so the 22 other children were in different areas, or they were free to move around during Aistear, so some were doing junk art or construction, or role play some were doing tabletop activities or colouring playdough, so it was quite busy and there was a lot of background noise. But the children were still interested in Beebot and a lot of the other children at times would stand around behind me to watch what was going on and because they were curious and wanted to see what was going on but they knew that they had to line up that if they needed me during Beebot that they had to stand and wait until I noticed and then they could ask their question.	Activity: Design, motivation (interest)		

TEA: It isn't something that I would do at the start of the year with Junior Infants. There's clear Aistear rules and boundaries but the children in the class are aware of the rules so it wasn't overly difficult like I felt it was more of a like I felt bad when a child would ask me to help them with something and I would be working with Beebot and be like I have to wait five more minutes and then I'll be able to help you. That was probably the bigger challenge was that I was like I can't be in two places at one time to help them but discipline wise at times the noise level got a little bit loud, but I felt that once they were reminded once that we were indoors that it was fine.	Activity: Design- how to ensure balance		
TEA: yeah, but there was definitely one or two but that being said those who I would have predicted weren't this strong character with Beebot didn't necessarily play out as the strongest child with that given activity. There was a few children that surprised me with how well they were able to programme Beebot and use their Irish.	Activity: Group design unexpected leaders		
TEA: That's good to hear. I think once they knew it was fair, they were fine they were fine with the amount of turns they got once they got a turn. I do think for the children to have adequate amount of turns five is well there was six in one of the groups. It was a big enough group really you wouldn't want the group much bigger than five or six.	Activity: design group numbers		
TEA: Because otherwise they would be sitting there idle, and I know you made those pages to keep them on task while they were waiting for their turn. They helped some of them but some of them sometimes they were bigger challenge than they were worth. You know what I mean?	SCT: Physical scaffolds		
TEA: Maybe it's more of a reflection that I just gave them and was like didn't spend enough time explaining them but, in my head, I was just giving them something to keep them focused or kind of focused while they waited their turn.	SCT: Physical scaffolds and their purpose		
TEA: Yeah. I just kind of left I was like they can look at them even the little pictures what was good about them was <u>every time they picked it up, they were saying the Irish word. So, they might have said it ten times in a row because they picked up the same mac tíre up ten times.</u>	SCT: Physical scaffolds and their purpose		
TEA: Yeah, I would definitely use Beebot again em. <u>I'm between two minds if I would use Beebot in other curricular areas because I know how beneficial it can be or would I save it for the novelty and the motivation it brings to learning Irish.</u>	Activity: the next step where does Beebot fit in		

TEA: Yeah, like I know it would be beneficial I would hate to overuse it and the novelty to wear off. But I do know how great it could for teaching phonics and spellings, cvc words anything like it does have endless opportunities. But that is something that I need to look into a little bit more even talking to you another time to see what you think and if you have advice on it. Em definitely another observation you might have this recorded yourself is that the children's feedback questionnaire didn't necessarily match my observation with regards to the children's learning or their enjoyment of the activity. OC2 definitely springs to mind. He loved it and was very good at it and then said the opposite then in the survey.	Attitudes: Questionnaire didn't match up		
TEA: Yeah. They're just not it's not that they're not able they're just not comfortable with a focus group, are they?	Attitudes: Gathering feedback		
TEA: Em positives was that it definitely motivated the children to do they thoroughly enjoyed using Beebot also its cross-curricular so its handy. But they were motivated by Beebot and there was definitely and increase in their vocab. Em and it motivated all of them like children I had never heard use a word of Irish before then heard using a good few word. That was impressive. And some children who would always pick up the vocab had more opportunities in a small group to extend their vocab. I just enjoyed working with the small group just from my own personal level because when you're teaching Irish to the whole class you spend half the time trying to motivate the ones who are not overly interested in it. So, it was nice to get to work with all levels of interest and encourage them and push them on.	Activity: the positive impact on the children and the teacher's perpective and the opportunities it afforded them		
TEA: The negatives em the fact that we were doing it every day I was sometimes a bit aaaah because I didn't essentially, I didn't do any of the role play well I did very little role play for the whole month in Aistear. So that was bit of eh I felt like I was neglecting something else you can't be everywhere at the one time. So maybe if I was doing it with Aistear again, I do think Aistear is the best time to do it I don't have a better time suggestion, but I do think maybe if Beebot was in Aistear Monday, Tuesday, Wednesday and not in Thursday, or Monday Wednesday Friday and not on Tuesday Thursday or something like that.	Activity: Long term Integration in a busy classroom		

Appendix W Thematic analysis: cycle four focus groups

1. Activity	Ownership and agency	18
	Scaffolding	
	Outlier: camera usage	
	Collaboration	
2. Computational Thinking	Algorithmic thinking	14
	Debugging	
3. Language		13
4. Attitudes		13

Child code from activity	Focus group No	Quote	Code/ Annotation	Theme	
P3	Group 1	CH3: We made up stories and stuff like that and we did the Trí muicín story. REA: Very good. And what language were you using when you were doing that? CH3: As gaeilge.	what was the purpose of activity	Activity	
P1	Group 1	What did you think of it? CH1: I pressed the buttons on the back of it. REA: Very good anything else? TEA: Why did you press the buttons? CH1: Because that was my favourite part of it. REA: And what did that do? CH1: Then I pressed the go button, and he was going. REA: He was going? CH1: Where I wanted him to go. Well sometimes he goes off the mat. REA: And when does he go off the mat? CH1: Mmmmmm REA: How does that happen?	Directing Beebot and giving him instructions Beebot going off track	CT: Algorithmic thinking Debugging	

		CH3: Because we press a lot of buttons too much, he goes off the mat. REA: He loses his way, does he? CH1: Yes CH1: And then and then if you realise, he's going off the mat you might need to press backwards at the end.			
Y5	Group 1	TEA: Why did we want Beebot to move? CH2: The pictures	The prompt for the activity	Activity	
P3	Group 1	REA: Do you think using Beebot helped you with your Gaeilge? CH3: Yes REA: Tell me a little bit about that CH3: Because you get to learn all the stuff about the other types of words on the other type of Gaeilge REA: So, what other type of words do you mean CH3: Like eh like eh words that we don't know we get to learn more about different types of words	Learning Irish with the activity extending new vocab	Language	
P1	Group 1	TEA: Why was it easier using Beebot to learn the words CH1: Because he moved to the things TEA: He moved to the things, ok. REA: What was your favourite thing about using Beebot? CH1: Watching him move	Moving Beebot and directing him around the mat	Algorithmic thinking	

P1	Group 1	CH1: Prefer to do it by myself	Doing it as a group or individually	Collaboration	
P3	Group 1	REA: What about you what was your favourite thing first? CH3: Pressing the buttons and watching him move. REA: And what did you think about doing it as a group? CH3: I liked doing it with all my friends and stuff. REA: Ok and did your friends instruct you or tell you where to send Beebot? CH3: Yes. REA: And you liked that did you? CH3: Yes.	Doing it as a group or individually	Collaboration	
Y5	Group 1	CH2: Didn't like using Beebot	Negative towards activity	Attitudes	
Y5		REA: And would like to keep using Beebot? CH2: Yes	Contradictory response to above	Attitudes	
CH2	Group 2	CH2: Yeah. It was really fun for me.		Attitudes	
		CH3: I put a no on the thing. REA: Yeah, you put a no on it. Why did you say no then? CH3: Because I REA: Why did you think it wasn't fun? CH3: Because I don't know all the Irish sometimes. Sometimes I forget it.	The difficult with Irish sometimes makes the activity a challenge	Attitudes	Language
CH2		REA: And why was that? Why did you like using the Beebot? CH3: Because he can you can go to different places like the carr and someone else can go to the carr. REA: Yeah, so you can go lots of different places	Beebot's ability to move around Language identifying similar sounding words	CT: Algorithmic thinking Language	

		with the Beebot? CH3: Yeah. The carr sounds like car.			
CH2		CH2: Because I love when I press the buttons and sometimes, he goes the wrong way and off the mat that really funny	Directing Beebot and giving him instructions Beebot going off track	CT: Algorithmic thinking Debugging	
CH2		REA: Did you think it was really good to help you learn your Irish? Ch2: Yeah. REA: Why was it good? CH2: Because he could Beebot could help us and show us the way to go.	Linkage between Beebot and language on the mat	Activity	Language
GC1 GC2 GC3	Group 3	REA: Now so I saw some amazing work with Beebot. So, I want to hear from you what did you think about it? CH3: I liked it. CH1: Yeah	Positive response about the activity	Attitude	
		REA: What was good about it? CH3: Em I liked pressing the buttons CH1: I liked when it gets off the mat and we can press the buttons.	Inputting the code and Beebot going off the mat	CT: Algorithmic thinking Debugging	
GC3		REA: Was it so funny when you people push the buttons, and he went off on travel off onto the floor CH1: Yeah, and sometimes it went by me and by my foot and it tickled me	Enjoyed when it came close as it went off the mat	Atttitude (happy)	
GC1 Ethan		REA: What was fun about it? CH3: I liked I liked when he was like moving and you got to press the buttons	Enjoyment of inputting the code and making Beebot move	CT: Algorithmic thinking	

		CH1: You say whose turn is it to say who should do it and who should say it where to go REA: Anything else Ethan? CH3: You have to like tell them where to go and tell them which buttons to press REA: And were you telling them that in English or in Irish? CH1: Irish CH3: Em Irish yeah	Describing how to do the activity and linkage to irish Language	Activity	Language
GC3		CH1: Yeah, even at home I do lots Irish and things. REA: So, I heard from the last group if they're walking home with their minder or their mammy that they're saying oh we go ar aghaidh or we to turn ar dheis now or we need to turn ar chlé? Does that ever happen to you guys? CH1: Yeah, for me it does. I get mixed up because we are also Lithuanian. My mam didn't really know Irish and then I teached her and she teached me. REA: Oh, wow so you're teaching each other Irish now? CH1: nodding REA: so, what languages do you speak? CH1: Speak English Irish and then Lithuanian too REA: And Lithuanian REA: So, which one do you use mostly at home? CH1: At home we use Lithuanian most	Learning Irish and linkng it to home. Mulitlingual home environment with positive outlook towards language learning	Language	

		REA: What else would you change? Is there anything you would like to change or is it just perfect and you would love to keep doing it? CH3: I want to keep doing it CH1: I want to keep doing it. REA: What's the bit you enjoy most about it? CH1: I like pressing the buttons REA: So, you like coding Beebot CH1: I would like to make our own pictures and just put them in	Positive to keep going with it and enjoyed pressing the buttons. Would like to make the activity more their own.	Activity: ownership/ agency	
CH3 GC5 CH2 GC6 CH1 GC4	Group 4	REA: So, they were doing Beebot REA: What is it doing Beebot? CH3: Like Irish	Association between Beebot and Irish	Activity	Language
		REA: Why was it fun? CH2: Because I like using Beebot and the buttons. REA: And the buttons you like pressing the buttons. CH3: I like eh em like the words REA: The words. So, did you like doing your Irish words during this activity? CH3: Yeah REA: Did it make learning Irish fun? CH3: Yeah CH1: And I thought it was funny when Beebot went off the mat. REA: Yeah, I know lots of people said they thought it was funny. CH3: It's not funny for me.	Enjoyed pressing the buttons and doing it through Irish. Liked when Beebot went off the mat.	CT: Algorithmic thinking Debugging	Language
		CH1: Sometimes I forgot siar. Sometimes I thought siar was front. REA: You thought siar	Difficult with directing Beebot	CT: Algorithmic thinking Debugging	

		was ar aghaidh? CH1: Yeah, then he just went off the mat and I went oh no.			
		CH2: I like change about it it's fun when its playing and its playing REA: Say that again you'd like to change what? CH2: I'd like to change Beebot, Beebot sleeping, I like Beebot sleeping, and I like playing with Beebot. REA: You like playing with Beebot. So, is there anything you would like to change? Is there anything you would like to do differently? CH2: Shaking head (no) REA: No. You like it the way it is? CH2: Yeah	Enjoyed playing with Beebot	Attitude	
		CH2: Yeah. I think I'm going to get a Beebot for my birthday	Positive towards Beebot that would like their own	Activity: ownership/ agency	
CH1 YC3 CH 2 YC1	Group 5	CH1: I liked doing Beebot moving and saying the words we wanted him to say.	Enjoyed directing Beebot and him saying the irish words, controlling Beebot	Attitude	
		CH2: The last time when we were doing Beebot and Rupak wasn't there it was like kids saying something it wasn't like ar chlé or whatever CH1: That was recorded in a different language REA: what language was that recorded in? CH1: It was like one of our classmates or Kelly's em people talking through the Beebot it was ar chlé ar aghaidh I	Recognises the issue that arose with Beebots recording of the word right.		

		think REA: Ar dheis. So, the last time what was different about the last time? CH2: It was like saying the different word vvvvvv			
		REA: Do you know what that language is? CH1: Yeah REA: What language? CH1: It's like say I'm driving a car and I'd say stop and the policeman says ar chlé then I go ar chlé like another person go ar aghaidh I go ar aghaidh.	Linking the Irish directional language to something observed in real life or in a cartoon.	Language	
		CH2: We do that walking as well. When you walk you need to go that way you go that way. REA: So, do you use those words after school? CH2: Yeah REA: And who are you using those words with? CH2: My mom and my childminder and my dad and whoever collects me from school	Linking the Irish directional language to something observed in real life	Language	
		REA: Why was it fun? CH2: Because we got to press the buttons and it was fun because when we're doing Beebot I didn't know what to do and we were doing Aistear normally other people do it Beebot so its funner when we're doing Beebot because we don't have to like play and I don't have to decide orla had decide who was doing Beebot and we em we like I can't remember	Enjoyed the activity, pressing the buttons and it being chosen for them.	Attitude	
		CH2: And like we coloured in our own characters and made our	Making the activity their own seeing	Activity: ownership/ agency	

		own things, and they could be anything that you want, and we put them in the blank Beebot mat. And if you say go to the unicorn you go to the unicorn.	their own pictures on the mat.		
		Did you find it tricky to think about the instructions? CH1: No CH2: No no if you go like that, you go straight ahead and then ar chlé and then all the way up to it. CH1: It's sometimes hard when Beebot is on the dochtúir and someone asks you to get it to the páirc. REA: yeah, cause its so far away? CH1: yeah Ch2: yeah, sometimes it's a little bit tricky sometimes it's easy because like CH2: and then sometimes you go to there	Activity is hard when there is a long journey for Beebot to do.	CT: Algorithmic thinking Challenge	
		REA: So how did you figure that out? Did you count the steps? Did you imagine it in your head? What did you do? CH2: We just like imagined it in our head	Visualing the route for Beebot	CT: Algorithmic thinking	

		REA: What about you what did you do? CH1: I well I just looked at the Beebot mat, and I tried to count the squares in my head REA: Yeah, ok and then we he needed to turn CH1: I just turned him the way I counted in my head REA: So, you are doing it all in your head. And did you ever count them with your hand? CH1: No because then the other people would see and then I would be cheating and so I was counting them in your head. REA: And was that one of the rules that you had to count them in your head and not with your hand? CH1: Well, I never tried it, and I don't think I will because counting in your head is better because you might not get a go and you skip over and then you have to say and then you go again and then skip over you and you don't get a turn. REA: And tell me is there anything you would like to change about this activity? CH1: Make it shorter REA: What do you mean shorter? CH1: Cause like I don't like missing out on things. Like Aistear and stuff cause that's our only play time we really get REA: So, you would like it to happen at a different time of day, so you didn't miss out on playtime	Visualing route for Beebot but didn't want others to see. Believed that it was cheating to verbalise the route. Activity was too long and wanted to do the other activities.	CT: Algorithmic thinking	

		CH1: Yeah. I'd like to have it after Aistear.			
		CH2: No because it would be too much people and it would be like I wanna go I wanna go. REA: And was it good when you Orla beside you to help you CH2: Yeah	Teacher assisting	Scaffolding	
		Did you like it when you were just doing it with our friends and Orla wasn't there or did you like it when Orla was there? CH1: I don't really know CH2: I don't really know either. I think I prefer doing it by ourselves because we get to do it	Doing as a group without teacher	Activity	
		CH1: Wait eh can I tell you something? REA: Of course CH1: I really wish you didn't have to use your Irish words CH2: Because sometimes we like forget them REA: That's ok though, isn't it? ALL: Yeah REA: Cause you're learning another language, isn't that, right?	Difficulty with the activity because of the Irish words and not knowing them.	Language	

		CH1: I know CH2: Yeah, cause growing up you have to learn all different language but when you're in little school you don't have to			
		REA: So, was it fun do you want to keep doing it? ALL: Yeah CH2: We do it every week. She always calls our name out cause it's on a list on our board do we get a cushion like one of those. CH1: I don't want to REA: is that because you want to do the other activities? CH1: yeah REA: You're sad to be missing out on them CH1: Yeah CH2: Is that why you're making that face? REA: And do you want to keep going with it? CH2: Yeah, we have a list and when our name is called out, we go and do it and others do the other activities. CH1: Yeah, and its cause it's so long. REA: Cause it's so long that's ok REA: And what if it was an option to do it? And you could choose which activity to do CH1: I would choose junk art CH2: I would choose Beebot	Positive and negative opinions on carrying on with Beebot. Choosing between play activities.	Attitudes	

CH1 OC3 CH2 OC4 CH3 OC5	Group 6	REA: Tell me a bit of story about that? What happened? CH1: Em we had to move Beebot on to all them pictures. CH2: But sometimes we did it too many times and he went off the mat. CH1: I see the tricky words	Purpose of the activity and Beebot going off track	Activity CT: Algorithmic thinking Debugging	
		REA: Tell me did you enjoy doing this? CH1: Yeah CH2: Yeah REA: Mia did you enjoy doing the activity CH3: Yes REA: It can be yes or no CH3: No	Mixture of positive and negative	Attitudes	
		REA: It's a no, is it? Roisin talk to me about this bit cause you were playing a lot with this bit at the back Mia. See these sheets and these pages here at the back? What were they? What were they for? CH2: Beebot mat REA: Yeah, tell me more CH2: You put them on, so you know what's next REA: So, you know what's next to do. So, I think I saw Orla saying Beebot is sitting on one thing and he's going to another, and did you have to put it on? Did you like doing that bit? CH2: Yeah CH1: No REA: No that's ok CH2: So, he had to go by himself (Beebot)	Using the scaffolds	Scaffolding	

		CH1: Oh, oh she's saying ar fheabhas to me CH1: I can't believe that CH1: Is that from the camera REA: Yes, it is from the camera REA: So, when you were putting all the instructions into Beebot was it really tricky to figure out ok Orla's asked me to go an páirc was it really hard to kind of imagine it and then put in the instructions? Ch1: No no actually yeah it was REA: And did he get easier and easier as you went on CH1: No CH2: Yeah CH1: No REA: From day one until now CH1: No CH2: Yeah REA: Was its great fun CH1: No, it wasn't fun REA: It wasn't fun, so you didn't like doing this CH1: Yeah, I love doing that REA: So which bit did you not like CH1: The little pictures on the REA: Card ok	Didn't enjoy using the scaffolds	Scaffolding	
		CH1: Yesterday we made up a new story the unicorn talked to much the driver went to sleep on the trí muicín fell out of the car, the bought some sweets ice cream and and then they fell asleep on the road. REA: So, tell me did you do that in English or in Irish?	Making the activity their own by making up a story	Activity: ownership/ agency	

		CH1: Irish. They sleeped on the road.			
		CH2: Unicorn and trí muicín REA: Unicorn trí muicín and they were in a CH2: Carr CH1: Unicorn talked so much the driver went to sleep and they fell out the door and there was sweets REA: Thit siad amach an doras agus bhí siad ag ithe milseáin and seacláid CH1: And smileys REA: was there smileys in the story CH2: Yeah REA: And was Beebot doing all the instructions were you telling Beebot where to go? CH2: Yeah CH1: Eh we pressed the buttons instead REA: You pressed the buttons and said téigh? CH1: yeah REA: and do you remember the instructions in Irish for Beebot CH2: Ar aghaidh, cas ar chlé cas ar dheis and siar REA: and siar. Do you remember what the green button is in the middle? Ch2: Téigh CH1: And in English it's go	Directing Beebot in Irish with their own story.	Activity: ownership/ agency	Language
		REA: And then this is a game that you're playing with Irish? CH1: No, it's called whatever you call it with Beebot the robot Beebot he's a type of robot	Identifying it as a game with Beebot not with Irish	Activity	

		REA: Why did you think it was a game? CH2: Because you had to have a turn and em at the end you could keep doing Beebot or do something else	Rationale for a game and having the option to continue	Activity	
CH1 OC2 CH2 YC4	Group 7	Ok so tell me about doing Beebot CH2: Its fun like because you get to press buttons and like our group was like the first one to do Beebot REA: And what did you do with Beebot? Did you do it in? Go on you tell me CH2: We did it in Irish and we talk to Beebot in Irish to get him to go to leaba or and like teddy and like Irish stuff. REA: And what kind of words did you use in Irish to tell Beebot where to go? Do you remember those words? What kind of words did you use? CH2: Em like cas ar chlé ar aghaidh, siar	Directing Beebot around the mat pressing buttons and doing it through Irish	Algorithmic thinking	Language
		REA: Why would you like to keep using Beebot? CH2: Cause it's fun REA: Did you like doing it with your friends in your group? CH2: Yeah REA: Was there anything you didn't like about it? Silence CH1: We loved everything CH2: Yeah, we did	Positive attitude towards the acitivty it's fun	Attitudes	
		CH2: The best bit is when he went off the mat REA: Oh really CH1: Yeah, cause he was like he pressed loads of the buttons and he went all over the floor right right and then the next	Beebot going off the mat	CT: Algorthmic thinking Debugging	

		time it went back on the mat and then next time it went back off the mat			
		REA: So, you use your books do you use anything else to learn Irish? CH1: We do CH2: The board REA: The board very good CH2: and definitely the computer or else the board wouldn't even work REA: Yeah, so did you like doing this activity ALL: Yeah REA: With Irish? ALL: Yeah REA: Do you think that you really really know your Irish words after doing this activity ALL: Yeah REA: Do you think you would know your words as well as you do if you didn't use Beebot? ALL: No CH2: We know our words from the board if we didn't have a board, we would not even know our words	Learning Irish usually with other resources. Don't see Beebot as contributing to learning language.	Language	
		Is there anything that you didn't like about it that you would like to change? So, if Orla said next week, we're going to do Beebot again what would you like to change? CH1: No camera	The recording of the activity	Activity: Research	

Appendix X Average task attempts per child

Orange	CH1	CH2	CH3	CH4	CH5		Children In	Attempts	Ave Attempts p child
Day 1	4	2	5	3	0		4	14	3.5
Day 2	4	3	3	3	2		5	15	3
Day 3	2	2	2	2	4		5	12	2.4
Day 4	0	4	2	4	4		4	14	3.5
Day 5	6	3	3	3	2		5	17	3.4
Green	CH1	CH2	CH3	CH4	CH5	CH6			
Day 1	3	2	8	7	4	0	5	24	4.8
Day 2	6	3	5	10	2	4	6	30	5
Day 3	2		3	7	2	3	5	17	3.4
Day 4	2	1	5	0	5	4	5	17	3.4
Day 5	3	1	4	3	4	5	6	20	3.3
Yellow	CH1	CH2	CH3	CH4	CH5				
Day 1	7	5	3	7	14		5	36	7.2
Day 2	2		4	6	6		4	18	4.5
Day 3	7			9	11		3	27	9
Day 4	7	6		3	3		4	19	4.75
Purple	CH1	CH2	CH3	CH4	CH5				
Day 1	4	6	7	12	5		5	34	6.8
Day 2	8	5	4		3		4	20	5
Day 3	3	5	3		6		4	17	4.25

Appendix Y Average attempts per task

Orange	CH1	CH2	CH3	CH4	CH5		Attempts per tasks completed
Day 1	2	2	2.5	1.5			2
Day 2	2	1.5	1.5	1.5	1		1.5
Day 3	2	1	2	2	2		1.714285714
Day 4		2	1	2	1.333333333		1.555555556
Day 5	3	1.5	1.5	1.5	1		1.7
Green	CH1	CH2	CH3	CH4	CH5	CH6	
Day 1	1	1	2	1.75	1.333333333		1.5
Day 2	2	1.5	2.5	3.333333333	1	2	2.142857143
Day 3	1		1.5	3.5	1	1.5	1.7
Day 4	1	1	2.5	1.666666667	4		1.888888889
Day 5	1.5	1	2	1.5	2	2.5	1.818181818
Yellow	CH1	CH2	CH3	CH4	CH5	CH6	
Day 1	2.333333333	1.666666667	1.5	3.5	4.666666667		2.769230769
Day 2	1		2	2	2		1.8
Day 3	2.333333333			2.25	3.666666667		2.7
Day 4	3.5	3		3	1.5		2.714285714
Purple	CH1	CH2	CH3	CH4	CH5		
Day 1	1.333333333	1.5	2.333333333	2	2.5		1.888888889
Day 2	1.333333333	1.25	2		1.5		1.428571429
Day 3	1.5	2.5	1.5		3		2.125

Appendix Z Sample of task complexity coding

Orange D1	Attempts	No. Tasks	Task 1/Attempts	Task complexity	Task 2/Attempts	Task Complexity
OC1	4	1	Task 1:4 Attempts *TEA: Chuir Beebot sa leaba. *CH1: 0[% presses right]. %comp: $ALG: BOT *TEA: Ah brú x ar dtús. *CH1: 0[% presses x, right, right]. *TEA: Ok you have brúigh ar dheis ar dheis so cad faoi ar dheis amháin casadh amháin. %act: physically moving the robot to show the directions Nathaniel has inputted. %sct: $SCA: TEA *TEA: Brú x ansin. %act: presses x. *CH1: 0[% Nathaniel presses right and forward]. *TEA: Agus? %sct: $MED: MKO: TEA *CH1: 0[% presses forward]. %comp: $ALG: BOT *TEA: Iontach agus cad a déanann tú anois? *CH1: 0[% presses go]. %comp: $ALG: BOT	x right forward forward go	Task 2:3 Attempts *TEA: Ceann ok Nathaniel. *TEA: Gortaigh Beebot a ceann. %sct: $SCA: TEA *CH3: 0[% Rotates Beebot physically around and points out course]. *CH5: Where's the ceann? %act: Pointing to relevant picture *CH1: 0[% presses forward]. *CH3: Don't touch that. %act: pushing Nathaniel's hand away presses forward, forward, left, go. %comp: $ALG: BOT *BEE: Didn't press x so had an extra forward from previous code. *BEE: Goes off the mat. *CH3: Oh no. %act: Picks up Beebot to bring it back to where he started *CH5: I said ceann. *TEA: Nathaniel did you get it? *CH1: 0[% presses x, forward, forward, forward, left]. %comp: $ALG: BOT *CH3: No, he went off the mat and then. *TEA: Ok. *CH3: 0[% leans in to do the coding again]. %comp: $ALG: BOT	x right forward forward forward forward forward go

Orange D1	Attempts	No. Tasks	Task 1/Attempts	Task complexity	Task 2/Attempts	Task Complexity
					*TEA: CH3 its CH1's turn. *CH1: 0[% presses forward, go]. %comp: $ALG: BOT *CH3: Yay. %act: Clapping hands	
OC2	2	1	Task 1:2 Attempts *CH2: Tell me which one which one? *CH1: That one. %sct: $SCA: CHI *CH3: 0[% points to picture of teddy's head]. %sct: $SCA: CHI *CH2: Ceann? *CH1: Yeah. %sct: $SCA: CHI *CH3: Press x. *CH2: 0[% presses x]. %comp: $ALG: BOT *CH3: Don't press go ok press go. %sct: $SCA: CHI *CH2: 0[% presses go]. %comp: $ALG: BOT *BEE: Alert noise. *CH2: 0[% presses forward, forward, forward, forward, left, left, go]. %comp: $ALG: BOT	x forward forward forward forward left forward forward forward go		
OC3	5	2	Task 1:4 Attempts *CH3: 0[% presses backwards, looks at the pictures and directions]. %comp: $ABS: BOT *CH3: 0[% presses right, forward four times]. %comp: $ALG: BOT *CH3: Oh no. %act: Shakes head leaning forward to pick up Beebot as he goes the wrong way.	x left forward left forward forward forward forward forward go	Task2:1 Attempt *CH3: 0[% presses x, forward, forward, forward, forward, go]. %comp: $ALG: BOT *CH2: Carr. *CH3: 0[% turns Beebot around and presses x]. *CH3: Ok so press that one that one and that one. %sct: $SCA: CHI *CH4: 0[% presses	x forward forward forward go

Orange D1	Attempts	No. Tasks	Task 1/Attempts	Task complexity	Task 2/Attempts	Task Complexity
			%comp: $DEB: LANG *TEA: Oh no lig dó. *CH2: 0[% squealing with excitement]. *TEA: Ok AJ an bhfuil Beebot sa pháirc? *CH3: 0[% shakes head]. *TEA: Níl Beebot sa pháirc. *CH3: 0[% Leans forward to get him]. *TEA: Ah fág é cá bhfuil Beebot? *TEA: Tá Beebot ar an talamh. *TEA: Cá bhfuil Beebot ar an talamh ok. %act: Teacher replaces Beebot on mat facing in the direction of the park *TEA: Ok fan soicind AJ. *CH3: Yeah. *TEA: an chuirfidh tú Beebot go dtí an pháirc. *TEA: ba mhaith le Beebot dul go dtí an pháirc. *CH3: Ok. *CH3: 0[% presses forward 3 times and right but forgets to press x]. %comp: $DEB: BOT %comp: $ALG: BOT *BEE: Beebot goes wrong again because AJ forgot to press x. *CH1: That is broken. *TEA: Níl sé briste. %act: Picks up Beebot. *CH1: It's broken if it goes the wrong way. *CH3: That’s mad.			

Orange D1	Attempts	No. Tasks	Task 1/Attempts	Task complexity	Task 2/Attempts	Task Complexity
			*TEA: AJ déan é uair amháin eile. %act: Places Beebot back on the mat *CH3: Yeah. *TEA: brú x ar dtús. %sct: $SCA: TEA *CH3: 0[% presses x]. *TEA: So, you are going to ar aghaidh ar aghaidh. *CH3: Ar aghaidh, Ar aghaidh, Ar aghaidh, Ar aghaidh, Ar aghaidh, Ar aghaidh and ar dheis. %comp: $ABS: LANG %comp: $GEN: LANG *CH3: 0[% AJ plots out route for Beebot]. *CH3: 0[% AJ points to squares and calling out directions to match]. %comp: $ALG: LANG *CH1: Orla what would happen if you just pressed go. *TEA: He would just do all the things you asked him to do the last time. *CH3: 0[% presses forward four times]. %comp: $ALG: LANG *CH3: 0[% stops to count out steps, goes back presses forward, right and go]. %comp: $ABS: BOT *TEA: Maith fear AJ. *BEE: Beebot stops one forward step short. *TEA: Beagnach ann AJ brú x uair amháin eile.			

Orange D1	Attempts	No. Tasks	Task 1/Attempts	Task complexity	Task 2/Attempts	Task Complexity
			*CH3: 0[% presses x, forward and go]. %comp: $ABS: BOT *CH3: Go!			
OC4	3	2	Task 1:1 Attempt *TEA: Róisín chur Beebot ag dul isteach sa charr? *TEA: Brú x ar dtús. *CH4: 0[% presses x, forward, forward, right, forward]. %comp: $ALG: BOT *CH3: And now go. %sct: $SCA: CHI *CH4: 0[% presses go]. *BEE: Makes it. *CH3: Yay. *CH4: 0[% smiling looking at teacher].	x forward forward right forward go	Task 2: 2 Attempts *CH4: Where do I have to go? *CH2: Carr. *CH3: 0[% turns Beebot around and presses x]. *CH3: Ok so press that one that one and that one. %sct: $SCA: CHI *CH4: 0[% presses forward, forward, left, forward]. %comp: $ALG: BOT *BEE: All fine until AJ physically turns Beebot as he aligns him on the mat. *TEA: AJ! *CH3: Aw no. *TEA: Beagnach ann cur céim amháin eile isteach. %sct: $SCA: TEA *CH5: Nearly there. *CH3: Now press x. %sct: $SCA: CHI *CH4: x. %act: presses x. *TEA: Agus ar ar aghaidh. %sct: $SCA: TEA *CH4: 0[% finger hovers over the right turn button]. *TEA: Where do you want Beebot to go? *CH4: Carr. *CH3: So, press	x forward forward left forward go

Orange D1	Attempts	No. Tasks	Task 1/Attempts	Task complexity	Task 2/Attempts	Task Complexity
					backwards. %sct: $SCA: CHI *TEA: You could go siar. %sct: $MED: MKO: TEA *CH4: 0[% presses backwards]. *TEA: And then cas. *CH4: 0[% finger hovers over right button]. *TEA: Yeah. *CH4: 0[% presses right]. %comp: $ALG: BOT *TEA: And then you'll need to go ar aghaidh. %sct: $SCA: TEA *CH4: 0[% presses forward]. %comp: $ALG: BOT *TEA: Yeah, agus brúigh téigh. %sct: $SCA: TEA *CH4: 0[% presses go]. %comp: $ALG: BOT *BEE: Makes it.	
OC5	0					