Teachers' Experiences of the Implementation and Teaching of the Coding and Robotics Curriculum in Primary Schools

By

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Thesis submitted to the School of Education, University of KwaZulu-Natal in the Discipline of Educational Leadership, Management and Policy in fulfilment of the academic requirements for the degree, Doctor of Philosophy

School of Education

College of Humanities

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2025

DECLARATION

I, Pranitha Chunder, solemnly declare that **"Teachers' Experiences of the Implementation and Teaching of the Coding and Robotics Curriculum in Primary Schools"** is my original work except where otherwise indicated. This work has not been submitted for any degree or examination at any other university. This thesis does not contain other persons' writing, data, pictures, graphs, or other information, unless specifically acknowledged as being sourced from other researchers. All the sources used and referenced have been acknowledged.

Signed [redacted] Date: 29/11/2025

STATEMENT BY THE SUPERVISOR

This thesis was submitted with~~/ without~~ my approval.

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USE OF ARTIFICIAL INTELLIGENCE (AI) DECLARATION

I Pranitha Chunder confirm that I made use of generative Artificial Intelligence (AI) in the preparation of this dissertation in the following ways:

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Pranitha Chunder (204004663)

ACKNOWLEDGEMENT

I express my sincere appreciation to the following people who have been instrumental in assisting me in compiling this thesis:

My supervisors, Dr Zanele Dube-Xaba and Dr Reginald Govender

Your academic guidance has been invaluable to me and has moulded me throughout this process.

The participants

Thank you to all the participants who selflessly gave me their time and shared their experiences of engaging with the Coding and Robotics curriculum. Without you, this thesis would not have been possible.

My friend and colleague, Kerishka Govender

I had reached a point of weakness and mental fatigue as I neared the end of this journey, and I prayed for the Lord to place someone in my life who would lift me up and stand with me as I managed the logistics of planning the workshops, interviews, and the collage-making session. You showed up – cool drinks in hand – ready to serve with your time, guidance, support, and encouragement. You were the angel sent to me during this journey. I pray that Jesus blesses you abundantly as you continue your journey, also as a PhD student.

My life group on Thursdays – Mum Lorna, Selina, and EJ

You have seen me cry out to the Lord and have prayed with me throughout my academic and professional journey in leadership. You have encouraged me and, most importantly, you have believed in me. Thank you for your love and prayers.

My best friend and author, Mandy-Rose Naidoo

“You know the people who feed your soul because you feel better after spending time with them.” You are one of the three people who entered my life and changed me for the better. I love you more than you will ever know. Thank you for believing in me.

DEDICATIONS

This thesis is especially dedicated to:

My Lord and Saviour, Jesus Christ

You have placed within me a fire that cannot be quenched until I have achieved academic excellence. I gratefully receive your purpose for my life – to be a voice to the voiceless in leadership.

My father, Mr Pradeep Bhal

My first meeting with my supervisor had to be rescheduled because it was on the day of your surgery. I still remember standing outside the theatre doors, praying for the entire seven hours while you battled a brain tumour. Although I have never told you this, I am deeply proud to be the daughter of the humblest man alive. You have been such a good father to me, and I am forever grateful for the countless hours you spent on the kitchen floor helping me with my homework.

My dear mother – my heart and soul

Thank you for understanding my temperament and for loving me as only a mother can.

My husband, Clinton

You have kept the home fires burning and supported me unwaveringly throughout my academic journey. You stepped in for me with our three children on days when I could not and did it so selflessly. You have been endlessly patient and have never uttered a harsh word to me in the 24 years we have been together. Thank you, Clint, for falling asleep with the light on while I worked through the night, fixated on my laptop.

My three children – Leah, Ethan Jude, and Trent Jude

You are my inspiration and my motivation to strive for contributions that will improve education, ensuring your future remains bright. My apologies for not always being part of your fantasy play. I have heard your laughter pass through the clicking of my laptop keys. You have had a blast! I hope you will forgive me, as you grow older, for the sacrifices that sometimes kept me away from you. You three were always the reason. Leah, being your mother is my greatest joy; you are the most beautiful girl in the world. Ethan, you are my pride. Trent, your hugs and kisses were somehow magical, they strengthened me as I sat at that table working late into the night.

My friend, Mr RR Pillay

It is said there are three types of friends: friends for a reason, friends for a season, and friends for a lifetime. You are all three to me. This thesis is dedicated to you because you have stood by me through every season of my life, especially the hard ones when I faced many Goliaths. I once told you I felt like giving up, you simply said, “Doctor sounds good next to your name.” Throughout my professional journey and in leadership, I faced many challenges, and you stood firmly by my side, cheering me on. I walked tall and proud because of your presence. You are one of the few left in this world with such integrity, unapologetically a man of your word. You have been my greatest support throughout this journey, and words fail to thank you enough.

Charlie - my most loyal and faithful friend

My Velcro Yorkie baby, you have sat on my lap from the very start of this journey until the end, even now as I type these words. You never left my side. Together, we endured sleepless nights, often going to bed at 2 am, you patiently waiting with me, and for me. Your name deserves to stand beside mine on this thesis. I will love you till my last breath on earth.

And I save the best for last – my late grandmother, Ms Leela Maharaj

You were the dreamer whose destination far surpassed all dreams. I lost you during the first year of my master’s journey, and I have yet to shed a tear because I have not yet faced the magnitude of your loss. My love for you transcends the universe. Who am I? I am my grandmother’s daughter. Ms Leela Maharaj, your legacy lives on.

ABSTRACT

This study explores teachers' experiences of the implementation and diffusion of the Coding and Robotics (C&R) curriculum in South African primary schools, with a particular focus on resource-constrained contexts. Guided by Rogers' (2003) Diffusion of Innovation Theory and Fullan's (1993; 2001) Theory of Deep Change, the study combines these theoretical perspectives into a conceptual framework that extends existing models by proposing a fifth stage - adaptation - thereby highlighting how schools contextualise curricular innovations to meet their specific needs. The conceptual framework developed in this study is termed the Adoption through Deep Change and Diffusion Model (ADCM). Methodologically, the research employs a qualitative design and draws on data generated through questionnaires, interviews, focus group discussions, collage-making activities, workshops, and reflective questionnaires with primary school teachers across different quintiles. The study involved ten purposively selected Foundation Phase teachers drawn from primary schools across Quintiles 2 to 5 in the Pinetown District, KwaZulu-Natal, representing a range of socioeconomic and resource contexts. Participants ranged in age from late 20s to mid-50s and included both experienced and relatively recently qualified teachers. The study uses thematic analysis to identify emerging patterns and subthemes.

The findings reveal that a complex interplay of emotions, structural challenges and adaptive practices shapes teachers' experiences. Notably, emotions such as frustration and fear resulting in feelings of intimidation were more pronounced among teachers in lower-quintile schools, whereas perseverance and hope were more evident in higher-quintile schools. Moreover, stumbling blocks - including limited technological resources, inadequate training, overcrowded classrooms and issues of inclusivity - emerged as significant barriers to curriculum diffusion. To address these constraints, teachers employed adaptive strategies such as integrating C&R into other subjects, utilising everyday resources, and adopting unplugged approaches to mitigate technological deficits and reduce learners' "nature deficit".

The study makes three key contributions. Theoretically, it extends diffusion and deep change frameworks to include an adaptation stage, thereby providing the conceptual framework for the ADCM. Pedagogically, the ADCM demonstrates creative strategies for teaching in resource-constrained environments. Practically, it offers recommendations for curriculum design and policy interventions. Overall, the findings underscore the need for systemic reform to ensure equitable access, continuous professional support and inclusive pedagogies. The study concludes that the successful implementation and sustainability of the C&R curriculum depend on teachers' ability to adapt the innovation to their contexts, supported by structural changes and interdisciplinary curriculum integration.

ACRONYMS AND ABBREVIATIONS

ADCM	Adoption through Deep Change and Diffusion Model (ADCM)
Coding	A set of instructions provided to a computer to perform specific actions or tasks (Akcay et al., 2018)
CAPS	Curriculum and Assessment Policy Statement**.**
DBE	Department of Basic Education
DOI	Diffusion of Innovation Theory
EEA	Employment of Educators' Act
ELRC	Educational Labour Relations Council
Robotics	Machine (microchip) that is programmed to perform tasks that humans would typically perform (Govender & Govender, 2021).
SMT	School Management Team
IDT	Innovation Diffusion Theory

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION TO THE STUDY

1.1 The Uncharted Territory

The implementation of Coding and Robotics (C&R) in South African public schools is currently being piloted in 1000 schools across five provinces (Rivett, 2019). Within the South African context, a pilot school refers to a public school formally selected by the Department of Basic Education (DBE) to implement the Coding and Robotics curriculum during its trial phase, prior to nationwide rollout, with approximately 1 000 schools identified for the Foundation Phase and Grade 7 pilot from 2021 onwards (Department of Basic Education, 2021). These schools were chosen to test the curriculum under real classroom conditions, provide the DBE with implementation feedback, and inform the full-scale rollout planned for subsequent years. Consequently, limited research has been conducted on this topic within the South African context. In South Africa, primary education comprises three phases: The Foundation Phase (Grades R–3), the Intermediate Phase (Grades 4–6), and the Senior Phase (Grade 7). As noted by Govender and Govender (2021), C&R is a newly introduced subject in South African schools; therefore, teachers generally lack prior experience and knowledge in this area. Moreover, the South African curriculum does not include coding instruction at earlier stages of schooling, as computer programming is only offered during the Further Education and Training (FET) band which is the final three years of schooling, (Govender & Govender, 2022; Govender & Govender, 2023). This study explores teachers' experiences in implementing C&R, the extent to which they feel adequately supported in the process, and the best practices that can be employed to adapt the C&R subject to their school contexts. This chapter introduces the study by outlining the background, problem statement, purpose, research questions, assumptions, significance, and limitations.

1.2 Background of the Study - Unveiling of the Threads

Imminent transformations associated with the Fifth Industrial Revolution (5IR), including advances in nanotechnology and artificial intelligence, as noted by Xu et al. (2022) are beginning to reshape global development trajectories. However, Mokotedi and Eloff (2022) argue that South Africa, as a developing nation, is still in the process of fully aligning with the demands of the Fourth Industrial Revolution (4IR). Despite this, the South African education system has formally committed to 4IR imperatives (Moloi & Mhlanga, 2021), and the Presidential Vision 2030 emphasises equipping children and youth with future-oriented skills and competencies. In this context, interest in and implementation of C&R as a school subject continue to expand both nationally and internationally (Arslan & Çelik, 2022; Otterborn et al., 2019).

As Adeaga (2022) asserts, advances in technology have spurred the Department of Basic Education's eagerness to implement C&R as a new subject in schools to equip learners to function in this digital, information-driven world. Most countries, including South Africa, have introduced C&R; however, Moloi and Mhlanga (2021) indicates that most schools in South Africa are not equipped to teach the subject. This is due to a lack of technological infrastructure in schools and expertise to properly implement C&R (Moloi & Mhlanga, 2021). Further to this, South Africa is severely short of digital skills, particularly in computer programming (Malinga, 2021) hence C&R unplugged was initiated by the Department of Education. (Greyling, 2023) opined that C&R unplugged was developed to expose learners to C&R skills without specialised technological

equipment. The aim of C&R unplugged according to Greyling (2023) is to create opportunities for learners from various social contexts in South Africa to be exposed to the subject, despite lacking the fundamental resources required to implement C&R.

Children are the most resilient group when it comes to adapting to rapidly developing technologies and our constantly evolving world (Baz,2018); hence C&R was first introduced to the primary schooling sector in South Africa. The objective was to produce digitally literate learners by providing them with the expertise, understanding, values, and attitudes that will equip them for the 4IR and to bridge the digital divide (Baz, 2018). The digital divide, as argued by Ndulu et al. (2022), stems from a lack of relevant networks, technology, infrastructure, digital proficiency, and skills.

Wing (2006) argues that all procedures, whether performed by humans or computers are underpinned by computational thinking. Consequently, computational thinking constitutes a fundamental skill that draws on the capabilities and limitations of computing processes, and should therefore be accessible to all learners, not only computer scientists. Developing this skill can enhance children's analytical abilities across the C&R discipline, providing an effective avenue for cultivating computational thinking, as learners must sequence commands to programme a robot (Govender & Govender, 2021). This underscores the need for schools to employ well-trained teachers who can facilitate computational thinking instruction. However, Bers et al. (2013) caution that many teachers have limited exposure to C&R and therefore possess insufficient knowledge of how to integrate robotics technologies into classroom practice. The lack of prior experience may lead to avoidance or superficial implementation, ultimately affecting the quality and consistency of the C&R curriculum across schools. This prompted the researcher to embark on research exploring primary school teachers' experiences of implementing the C&R curriculum within schools.

The manner in which teachers' experience Coding and Robotics is the focus of this study. Their experiences will ultimately determine the success or failure of the diffusion of Coding and Robotics within the schools. A deep understanding of the C&R curriculum influences teachers' experiences. Teachers with a deep understanding of the C&R curriculum exhibit a profound mastery of subject matter, demonstrating a comprehensive awareness of the content they are entrusted to impart to learners. Once there is a deep understanding of the Coding and Robotics curriculum, there will be a deep change that will occur, this being the adaptation of Coding and Robotics within schools. This deep change is determined by the proper diffusion of the C&R curriculum within schools which is ultimately determined by teachers' experiences and preparedness in implementing Coding and Robotics curriculum. Hence the theory of Innovation Diffusion and Deep Change were combined to form a conceptual framework known as the Adoption through Deep change and Diffusion Model (ADCM) which will serve as a lens to inform this study and will be discussed further in the study.

The rationale for this study stems from the researcher’s personal experience. Firstly, as a school-based teacher, manager and leader, the researcher understands the importance of integrating technology into classroom practices. The researcher views the teaching of C&R as essential, since it equips learners with critical skills necessary to navigate an increasingly technology-driven society. Secondly, the researcher was inspired by involvement as a master trainer in the C&R Unplugged programme for primary school teachers. Through interactions with teachers during training workshops, it was observed that although many expressed enthusiasms about the potential benefits of C&R, they also demonstrated fear

and a lack of understanding, which led to resistance toward its implementation in their schools. Thirdly, in developing countries such as South Africa, C&R remains a relatively new field that has not yet been extensively explored in existing literature.

1.3 Problem Statement – The Puzzle to be Solved.

C&R are widely regarded as innovative tools for enhancing teaching and learning (Julià & Antolí, 2016). The teaching of C&R in schools is crucial, as the majority of future occupations are expected to be technology-based. Research has revealed that the implementation of C&R across many countries has been challenging, with schools struggling to determine effective strategies for successful integration (Jantjies, 2020; Malinga, 2021; Rivett, 2019). In South Africa, these challenges include, teachers' limited subject knowledge, inadequate information technology infrastructure, poor internet connectivity, and school safety concerns (Rivett, 2019). Such issues suggest that the foundational requirements for the effective implementation of C&R in schools may not yet be fully established. In this regard, Jantjies (2020) emphasises that computers, along with the necessary Information and Communication Technology (ICT) infrastructure and reliable internet access, must be available on school premises to ensure a strong foundation for developing digital skills.

As asserted by Majoni (2017), the existing C&R curriculum is burdened by an excessive volume of content and expectations within limited timeframes for completion. Consequently, the implementation of the C&R curriculum may present additional challenges related to timetabling and curriculum coverage. Furthermore, the time allocated for C&R, as stipulated in the C&R curriculum and Assessment Policy Statement (CAPS) (DBE, 2021), reflects a constrained schedule: Grade R learners receive only one hour of C&R instruction per week, while learners from Grades 1 to 9 are allocated two hours per week. This limited allocation may further hinder comprehensive teaching and learning within the subject. Therefore, given that teachers play a central role in implementing the C&R curriculum, an in-depth examination of their experiences is essential. Insights gained from teachers' perspectives can provide valuable input to curriculum designers within the Department of Basic Education (DBE), informing more effective planning and support strategies for successful implementation.

Teachers are widely recognised as the key agents in implementing curriculum change. For any meaningful transformation to occur in the classroom, it is essential that teachers receive targeted professional development opportunities that enable them to fully embrace innovation and acquire the necessary knowledge and skills to implement new curriculum effectively. According to Fullan and Stiegelbauer (1991), it is teachers' beliefs, attitudes, and actions that ultimately determine the success of educational reform. In this regard, teachers' experiences in implementing the C&R curriculum represent a critical factor influencing their beliefs, attitudes and ability to improve the subject over time. Despite the government's intention to integrate C&R into the national curriculum, Mondada et al. (2016) argue that limited progress has been made in establishing meaningful professional development programmes to adequately prepare teachers for its implementation.

1.4 Objectives of the Study

The objectives of the study are listed as follows:

To explore teachers' current experiences in implementing the diffusion of the C&R curriculum in primary schools.

To examine the rationale for adopting non-digital (unplugged) pedagogical approaches in the teaching of the C&R curriculum.

To identify and propose strategies for adapting the C&R curriculum to align with the diverse contexts and needs of individual schools.

1.5 Research Questions

The study explores the experiences of primary school teachers who are implementing the C&R curriculum and seeks to respond to the following questions:

- *What are teachers' current experiences of the implementation and diffusion of C&R curriculum in primary schools?*
- *Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum?*
- *How can the C&R curriculum be adapted to effectively address the specific needs and contextual realities of the school?*

1.6 Significance of the Study – The Bigger Picture

Research conducted on C&R in South Africa focuses on the following: the use of robotics in programming instruction (Govender & Govender, 2023); Unplugged C&R; and the status of C&R in South African schools (Greyling, 2023; Rivett, 2019). Consequently, there is limited research focusing on teachers' experiences and practices of implementing the C&R curriculum in primary schools, particularly in South Africa. Due to the limited number of studies on the subject, teachers' experiences implementing the C&R curriculum can make an important contribution to the body of literature. This study seeks to contribute to the existing body of literature and inform future policymaking by proposing enhancements to the C&R curriculum through cost-effective and innovative approaches suited to the South African context. To achieve this, the study examines teachers' experiences with implementing the C&R curriculum in South African primary schools.

The experiences shared by teachers in this study served as a valuable guide for the researcher in understanding how the C&R curriculum was introduced and diffused among teachers. Specifically, the study sought to explore how the diffusion process occurred, what meaningful changes emerged during this stage, which best practices teachers employed, and how these practices were used to adapt the C&R curriculum to meet the unique needs of individual schools. To achieve this, the researcher gathered insights from teachers who participated in a series of five workshops focused on non-digital teaching techniques for C&R. During these workshops, teachers actively engaged with the instructional materials provided and shared reflective feedback on their experiences. This feedback was subsequently analysed and used to formulate recommendations for adapting the C&R curriculum to better align with the specific needs the schools.

1.7 Assumptions of the Study

The assumptions made regarding this study are as follows:

The data generation tool elicits reliable responses from the participants. The participants fully understand the questions and are given the opportunity to clarify any that may be confusing. The participants provide honest answers without fear of intimidation or breach of anonymity. Furthermore, the workshops are tailored to the South African context.

1.8 Limitations of the Study – The Blind Spots

The researcher is currently a master trainer of C&R Unplugged and has been part of the training of lead teachers in the Inkosi Albert Luthuli Region; hence, the participants in the study are lead teachers trained by the researcher. A limitation could be a power imbalance between the participants and the researcher, who serves as a master trainer. The researcher ensured that a trust relationship was established with the participants, in which the value and importance of participants providing accurate and truthful responses during the data-gathering instruments were emphasised. The participants were professional teachers employed independently by their own schools. The researcher had no authority over their employment, their salaries, their professional assessments or their careers. Participants therefore had no professional incentive to respond positively in order to please the researcher. In this study, the relationship between the researcher and the participants was that of fellow education professionals engaging collaboratively in a shared task. The research design, including the researcher's dual role as facilitator and researcher, was reviewed and approved by the University of KwaZulu-Natal's ethical committee before the study commenced. All participants provided written informed consent and were advised of their right to withdraw at any stage without consequence. Pseudonyms were used throughout to protect participants' identities and to reduce any social pressure that might have arisen from the researcher knowing exactly which individual gave which response.

Another limitation is that the researcher is collecting data only from teachers, not from learners. The learners' data could support the teachers' data. Further research collecting data from learners is necessary to address this limitation. An additional limitation is that, while there is a curriculum, there is no standardisation of the equipment schools must use when implementing the C&R curriculum. Depending on the individual schools' quintile, teachers' resources for implementation may differ, consequently, teachers' experiences are also likely to vary. The researcher identified the school's quintile and the resources available at each school to implement C&R before data generation.

1.9 Layout of Chapters

CHAPTER ONE - Introduces the study, provides background, presents the problem statement, outlines the objectives, specifies the research questions, explains the significance, identifies the assumptions and limitations of the study.

CHAPTER TWO -Presents a repository of pertinent literature from both local and international sources that informed and bolstered the study.

CHAPTER THREE- Provides a thorough explanation and account of the Innovation Diffusion Theory and the Deep Change Theory, which together formed the conceptual framework that underpinned the study. This chapter also includes pertinent literature that supports the interpretive paradigm that underpins the study.

CHAPTER FOUR- Presents the research methodology that was used in this study. This includes the epistemological perspective of the study, the research design, issues of trustworthiness, details of the participants, data generation methods, data analysis procedures, and ethical issues considered during the study.

CHAPTER FIVE - Part A: Presents the data collected from the first three phases of the study, namely: questionnaires, one-on-one interviews, and collages.

CHAPTER FIVE - Part B: Presents the second part of the data collected from the workshops, focus group interviews, and the reflective questionnaires.

CHAPTER SIX - Discussion of Findings. This chapter presents an in-depth discussion of the findings. The findings are presented in relation to the theoretical framework used to analyse data generation.

CHAPTER SEVEN - Implications, Propositions, and Recommendations: Towards a More Equitable C&R Curriculum. The recommendations were proposed, limitations of the research as well as the concluding remarks are presented in this chapter.

CHAPTER TWO: Coding and Robotics Curriculum Implementation - A Critical Literature Review

2.1 Introduction

Chapter One presented a summary of the study, detailing the research question, objectives, and significance of exploring teachers' experiences with integrating the C&R curriculum in primary schools in the Pinetown District which is situated in the Inkosi Albert Luthuli Region. Chapter Two examines important scholarly information to contextualise the study within academic literature.

2.2 Conceptualising C&R

The conceptualisation of Coding and Robotics (C&R) as an educational domain is not merely a technical exercise in defining terms; it is a philosophical and pedagogical act that determines who has access to digital knowledge, what counts as learning in a technology-driven age, and which institutional and cultural assumptions underlie curriculum design. To engage meaningfully with teachers' experiences of C&R implementation, it is therefore necessary to first locate C&R within the broader scholarly debate about what these disciplines are, why they matter, and what their introduction into compulsory schooling demands of teachers as knowledge workers rather than mere content deliverers. According to Aydoğdu and Turan (2022), C&R involve the creation of algorithms for specific purposes and the translation of these algorithms into programming languages that computers can execute. Building on this view, Kalogiannakis and Papadakis (2017) emphasise that C&R constitute essential 21st-century skills that foster problem-solving, critical thinking, communication, collaboration, flexibility, computational thinking, and creativity. In essence, C&R provide a foundation for the generation of new ideas and the cultivation of creative thinking. Similarly, Bers et al. (2013) describe C&R as a modern form of human expression that enables innovative modes of experiencing, reasoning, and communicating. Through this expressive capacity, it supports learners on their educational journey by equipping them with the skills needed to confront complex challenges and thrive in an information-driven, technologically advanced world. Furthermore, learners who engage in C&R tend to become more motivated, confident, and effective communicators and problem solvers (Mason & Rich, 2019). In alignment with these perspectives, Fragapane and Standl (2021) highlight that one of the key competencies developed through C&R is creative thinking, as learners engage in programming fundamentals such as pattern recognition, observation, abstraction, and visualisation, all of which nurture imaginative and analytical thought processes.

C&R was designed to expose children to a range of skills and values that foster creativity, build self-confidence, enhance motor development, and strengthen collaboration, problem-solving, and critical thinking abilities. Collectively, these competencies enable learners to function effectively in a digital, information-driven 21st-century society (Pooja, 2023). In recognition of its importance, the South African Department of Basic Education (DBE, 2021) incorporated C&R into the draft national curriculum, released on March 19, 2021, identifying it as an essential component for preparing learners to thrive in a technology-oriented world. Furthermore, C&R encompasses several interconnected domains within Engineering and Information Technology, engaging learners in tasks that promote computational and logical reasoning for effective

problem-solving (Pooja, 2023). Through the development of digital and ICT skills gained from the C&R curriculum, learners are empowered to enhance their academic learning and to address real-world challenges more effectively in their everyday lives.

Rastogi (2022) contends that our everyday lives are shaped by innovations that originate from the core principles of C&R; hence, the Department of Basic Education (DBE) has recognised the significance and value of introducing C&R as a new subject in schools. As asserted by Rastogi (2022), C&R help learners learn *how* to think rather than *what* to think, thereby fostering the development of essential problem-solving skills. Problem-solving, as noted by Eguchi (2017), is a fundamental ability that learners cultivate through active engagement in C&R exercises. Supporting this perspective, Benitti and Spolaôr (2017) concur that participation in C&R activities enhances learners' collaboration and problem-solving competencies. Similarly, Nemiro (2020) observes that learners who engage in C&R tasks are consistently interacting and collaborating with their peers, thereby strengthening their interpersonal and communication skills. In alignment with this view, Pedale et al. (2015) emphasise that the integration of C&R into the school curriculum can further promote learners' collaboration and teamwork abilities (Nemiro et al., 2017; Yang et al., 2020).

The scholarly consensus represented in this section, anchored in leading international studies by Kalogiannakis and Papadakis (2017), Bers et al. (2013), and Mason and Rich (2019), establishes C&R as fundamentally concerned with cultivating higher-order cognitive and collaborative competencies rather than narrow technical coding skills. Supporting studies, including Fragapane and Standl (2021) and Benitti and Spolaôr (2017), corroborate these claims across a range of pedagogical and developmental contexts. Yet a significant gap persists: while the international literature richly documents what C&R can achieve in well-resourced educational settings, it offers comparatively little insight into what C&R looks like from the experiential standpoint of teachers who must implement these competency goals without adequate training, resources, or institutional support. The South African context in which the DBE mandated C&R implementation in 2021 in a system characterised by stark socioeconomic inequality renders the existing definitional consensus insufficient as a practical guide. This study addresses that gap by centering the teacher's lived experience of conceptualising and enacting C&R under conditions that the dominant international literature does not anticipate.

2.3 Why Computational Thinking?

To understand why teachers' struggle with C&R implementation, one must first interrogate the cognitive demands that the C&R curriculum places on teachers. These demands that are rarely acknowledged in policy documents or professional development frameworks. Computational thinking is not a neutral technical skill; it is a distinctively disciplinary form of reasoning that requires teachers to reconceptualise how knowledge is organised, processed, and communicated. For teachers who trained in a pre-digital curriculum era particularly those in South Africa who received limited pre-service technology education, this represents not a curriculum addition but a fundamental epistemological challenge. Computational thinking is a term coined by Papert in 1980 and, according to Wing (2016), is the mental procedures involved in constructing problems so that both machines and people can solve them. The abilities that are required of learners for computational thinking include; the abilities to comprehend, evaluate, and break down a problem into a smaller problem, to identify sequences in issues, to reduce a problem by concentrating on the core ideas hence omitting unnecessary details, to develop a methodical approach to solving a problem and to test and debug

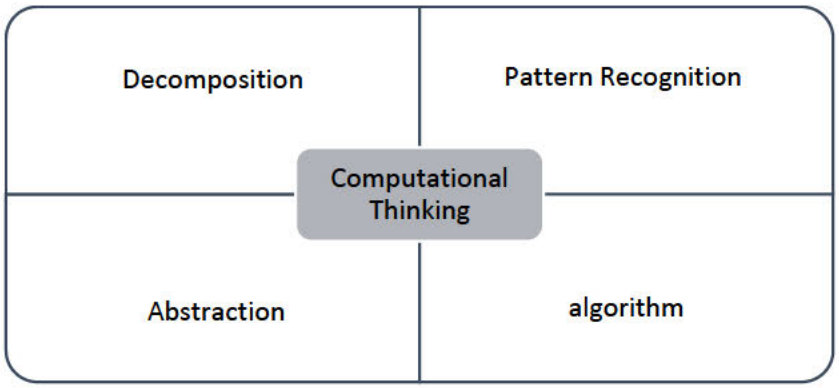
the solution (Shute et al., 2017). Computational thinking is a component of computer science that is integrated into educational robotics because of their shared objectives and targets (Shute et al., 2017).

Although computational thinking in education has gained increasing attention among educational practitioners and researchers, there remains limited understanding of effective approaches to teaching and learning it. In this regard, Su and Yang (2023) reviewed 26 studies published between 2010 and 2022 that examined computational thinking instruction and learning in early childhood education. Their analysis focused on the subject matter, pedagogical design, assessment techniques, and academic outcomes. The findings revealed that children can acquire the foundational concepts and skills of computational thinking together with related competencies such as problem-solving, cooperation and interaction when exposed to age-appropriate teaching methods. Consequently, nurturing learners' computational thinking skills from an early age is critical, as early childhood represents a developmental stage in which learners are most receptive to new forms of learning (Sriram, 2020). Computational thinking is therefore of particular significance, as it equips learners with the ability to identify problems, devise solutions, and apply programming and information-processing systems to navigate these challenges with skills that serve as the foundational basis for teaching C&R (Sriram, 2020).

Computational Thinking skills constitute a fundamental component of computer science and is regarded as essential to early childhood development, comparable in importance to literacy, numeracy, and writing (Wing, 2006). As argued by Wing (2010), computational thinking represents an advanced-level reasoning skill that equips the modern learner to engage in complex, higher-order cognitive processes. It enables diverse modes of thinking and fosters the development of logical capacity while mitigating the tendency toward repetitive or fixed cognitive routines. As the field of computational thinking has continued to evolve, numerous literature reviews have examined its pedagogical implications and applications (Hsu et al., 2019; Merino-Armero et al., 2022). These studies collectively indicate that much of the existing research has concentrated on on-screen programming activities that rely heavily on computing technologies. However, younger learners often experience challenges with such on-screen programming due to difficulties related to reading, writing, and typing, as well as underdeveloped fine motor skills required for effective use of a computer mouse or keyboard (Burleson et al., 2018). In this context, the Department of Basic Education (DBE, 2022) highlights four key elements of computational thinking-decomposition, pattern recognition, abstraction, and algorithm design. These core components will be discussed in greater detail in the subsequent section, accompanied by visual illustrations to enhance conceptual understanding.

Figure 2.3(a)

Elements of Computational Thinking

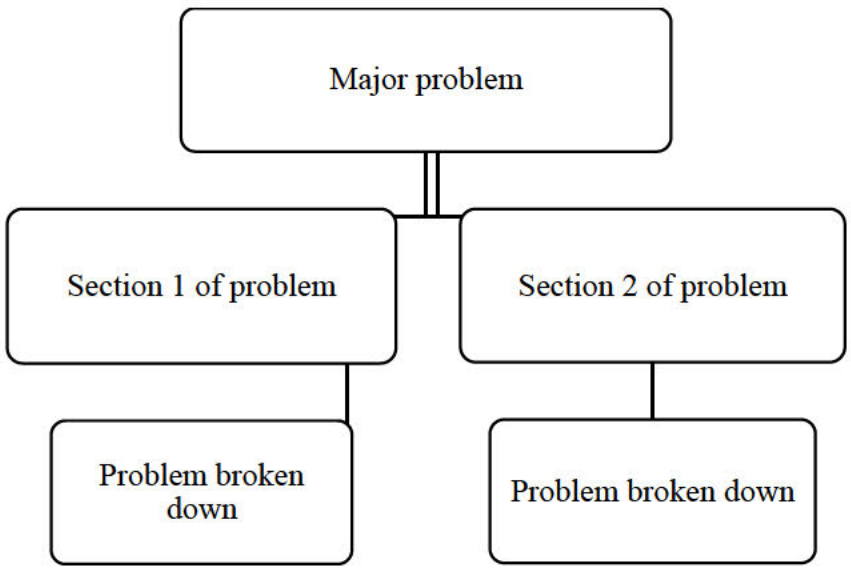


Note. Visual illustration created by the author and adapted from the Department of Basic Education (DBE), 2022.

Each of the elements of Computational Thinking is diagrammatically displayed separately below, followed by an explanation of each.

Figure 2.3(b)

Decomposition

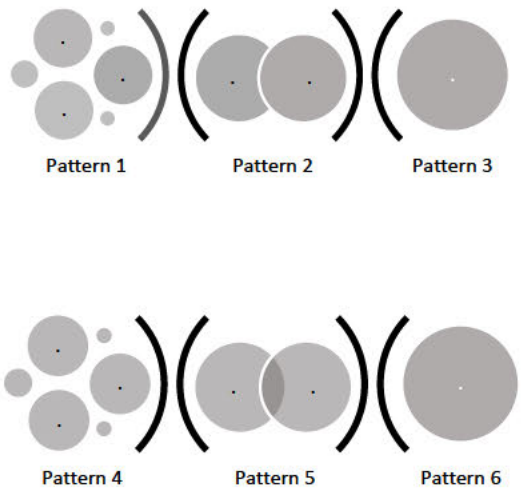


Note: Visual illustration created by the author and adapted from the Department of Basic Education (DBE), 2022.

Decomposition is breaking a problem down into smaller parts. You decompose the problem to find a solution. By decomposing a problem, it becomes simpler to solve. The illustration above depicts a major problem that is decomposed into smaller problems, which are then further broken down into even smaller problems.

Figure 2.3(c)

Pattern Recognition

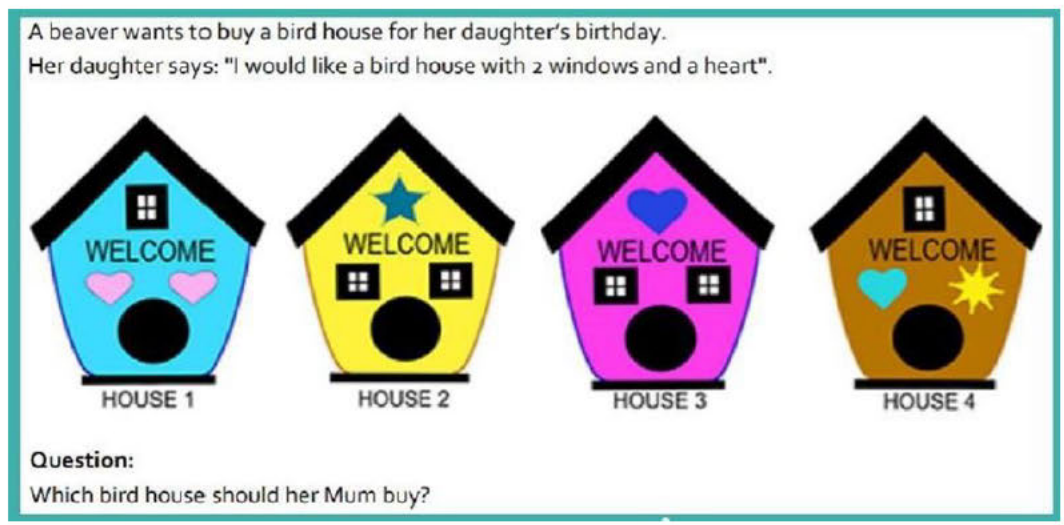


Note. Visual illustration created by the author and adapted from DBE (2022).

Pattern recognition involves recognising patterns in repetitive sequences when solving problems and identifying different patterns.

Figure 2.3(d)

Abstraction



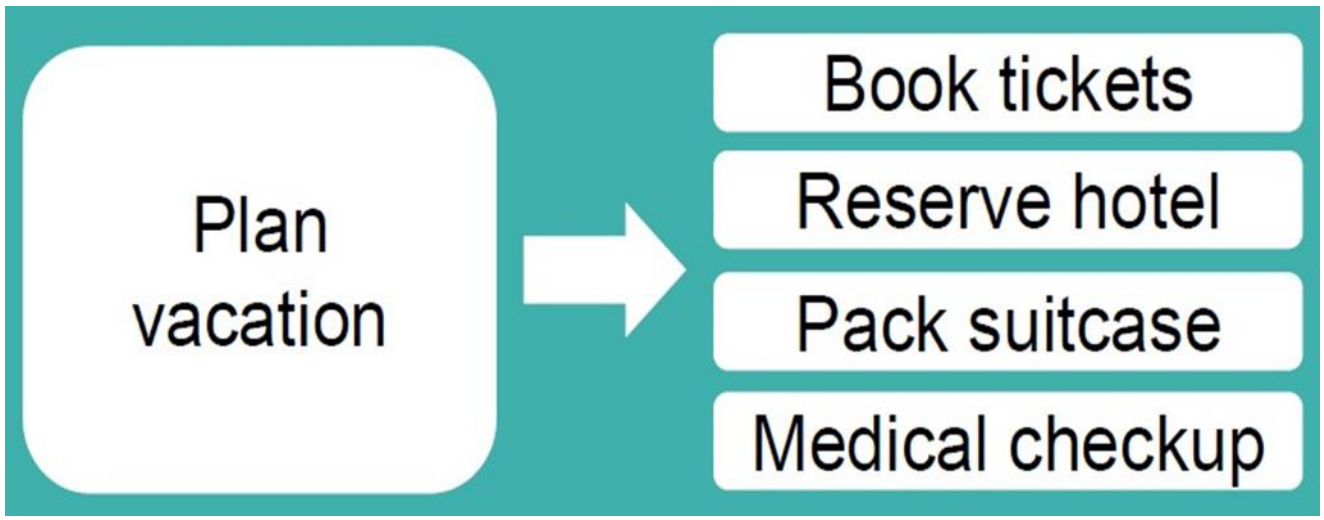
Note. Visual illustration adapted from Tangible Africa https://tangible.levafoundation.org

Abstraction involves filtering a problem by removing unnecessary information while focusing on the important parts, making it easier to solve, abstracting only the important parts of information to view the result. The image depicts a collection of birdhouses, each with varying shapes, windows, and decorative features. Using abstraction, one deliberately ignores extraneous details such as colours, textures, or ornamental patterns,

and instead focuses on the core features relevant to problem-solving. In this case, the essential elements are the number of windows, the presence or absence of a heart shape and the basic structure of the birdhouse. Abstraction allows learners to filter out unnecessary complexity and attend only to the criteria that matter for the task at hand in this scenario, identifying the correct birdhouse that fits the beaver's request.

Figure 2.3(e)

Algorithm



Note. Visual illustration adapted from Tangible Africa https://tangible.levafoundation.org

Algorithm, this means that you follow step-by-step sets of instructions to solve a problem (Kalelioglu, 2016). As depicted in the figure above, the purpose is to plan a vacation. The arrow points to four actions you should complete to organise your vacation:
Book tickets, reserve a hotel, pack your suitcase, and check in. You carry out these actions in a precise order by following a step-by-step set of instructions, which will be based on the order in which you will first need to start when planning a vacation.

Geldenhuys and Fataar (2021) found that the primary obstacle to effectively teaching C&R was a lack of knowledge of computational thinking skills required for learners to engage in C&R. The effective implementation of C&R according to Geldenhuys and Fataar (2021) are as follows: Provide professional development that focuses on the methods of instruction when integrating computational thinking skills in young learners, assist teachers on how to incorporate computational thinking skills into the teaching of C&R, mediate time limitations and provide the relevant resources. The foundational work on computational thinking is largely anchored in Wing's (2006; 2016) seminal theorisation, which established computational thinking as a core literacy comparable in importance to reading and numeracy which has achieved wide consensus in the education literature. Supporting studies, including Su and Yang's (2023) systematic review and Shute et al.'s (2017) component analysis, operationalise Wing's framework into pedagogically accessible elements. Geldenhuys and Fataar (2021) represent the most directly South African contribution, identifying professional development focused on computational thinking as the primary lever for effective C&R teaching. However, a critical gap remains: the existing computational thinking literature predominantly concerns itself with learner outcomes and curriculum design, while the

teacher's cognitive and emotional experience of acquiring and teaching computational thinking in under-resourced, high-inequality contexts remains under theorised. This study contributes to filling that gap by examining how Foundation Phase teachers in South African public schools construct, resist, and ultimately adapt their understanding of computational thinking within the constraints of the ADCM's diffusion and deep change framework.

2.4 Curriculum and Policy Dissemination and Implementation

Curriculum policy documents are, by nature, aspirational texts: they describe what should happen in classrooms, not what does. The translation of the DBE's C&R curriculum and its Assessment Policy Statement (CAPS) into lived classroom practice is a profoundly political and logistical process that depends not only on policy coherence but on the material conditions of schools, the preparation of teachers, and the cultural readiness of communities. To understand teachers' experiences of C&R implementation, it is therefore necessary to examine the policy landscape critically, not merely as a description of what was mandated, but as an analysis of the assumptions, contradictions, and silences embedded in the policy itself. The implementation of the National Curriculum Statement, which serves as the framework for South African education, is guided by the C&R Curriculum and Assessment Policy Statement (CAPS). Within this framework, Coding and Robotics (C&R) is introduced as a school subject in a phased manner: Grades R–3 and Grade 7 in 2023, Grades 4–6 in 2024, and Grades 8–9 in 2025 (Liebenberg, 2022). As of 2025, the full implementation of C&R has not yet been achieved, with access largely limited to a select number of schools in KwaZulu-Natal that possess the necessary technological resources. The data for this study were therefore drawn from pilot schools, which represent a small subset of approximately 1000 schools nationwide.

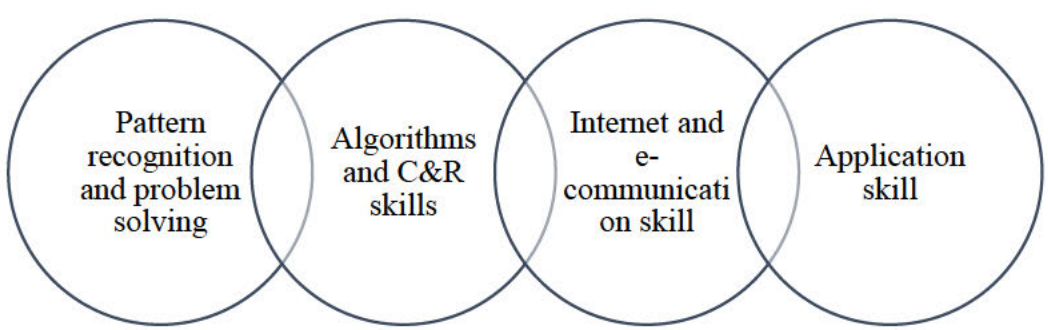
The CAPS document structures the C&R curriculum into five key strands: pattern recognition and problem-solving, algorithms and coding, robotic skills, internet and e-communication skills, and application skills (Department of Education, 2022, p. 25). These strands are elaborated according to the different phases of learning, with concepts introduced in the Foundation Phase and subsequently reinforced in both the Intermediate and Senior Phases. In support of effective teaching, the Department of Basic Education (DBE), in collaboration with teacher unions, has initiated professional development programmes to equip educators with the knowledge and skills necessary to teach C&R. Specifically, Foundation Phase teachers are expected to provide learners with regular, structured, and enjoyable free-play C&R activities that are engaging, developmentally appropriate, and manageable (DBE, 2022).

The focus areas of teaching C&R, informed by the CAPS Document, are pattern recognition and problem-solving, algorithms and coding, robotic skills, internet and e-communication skills, and application skills (DOE, 2022). The subject's distinctive study areas, as outlined in the draft curriculum, offer further insight into its unique breadth. The C&R curriculum is separated into four study areas for learners in Grade 4 through 9: algorithms and coding, robotic skills, application skills, and internet and e-communication skills. Pattern recognition and problem-solving are additional study topics in the Foundation Phase (Grades R to 3) to ensure that fundamental concepts and abilities are sufficiently established before moving on to the subject content in the intermediate phase. As the word “coding” suggests, the study areas imply that this subject covers

more ground than just the act of writing code (DBE, 2021). The methods used to teach C&R include highly structured demonstrations and explanations of content, direct and precise reasoning, with lots of scaffolding, teaching learners through game-based learning, and focusing on projects that utilise and encourage cooperative learning and problem-solving (McNulty, 2022). In the Foundation Phase, C&R begin with routine activities, such as indoor and outdoor free play, as well as structured problem-solving activities (DBE, 2022). In addition, C&R activities are learner-centred, fun and allow for experimentation and exploration rather than relying solely on instructions and directions (Paaskesen, 2020). The concepts mentioned above overlap and are linked to each other, and they are depicted in the following figure:

Figure 2.4(a)

The Concepts of C&R that Overlap Each Other



Note. Visual illustration created by the author and adapted from the Department of Basic Education (DBE), 2022.

Pattern recognition and problem-solving is an integral part of teaching C&R, as learners should be able to identify conceptual and geometric patterns to solve problems. The skills taught in this strand focus on predicting and solving problems to identify and analyse patterns in real objects, designs, and visual representations that exhibit abnormalities, recurrence, and changes in both number and size. Learners require these skills to use grids and symbolic languages to describe links and patterns to solve problems and identify coding patterns worldwide by examining lines, objects, and shapes.

Algorithm and Coding: For learners in Grade R, basic programming concepts and ideas are presented through hands-on coding exercises that build on simple, user-friendly platforms that are enjoyable for them to interact with, and progress to digital platforms from Grade 1 onwards. By utilising these digital platforms, learners are exposed to fundamental computational concepts and abilities, including the ability to recognise and evaluate solutions to specific problems and translate simple algorithms into block-based code.

Robotics Skills: Coding and engineering are two fields that combine to form robotics. The basic circuits and systems of mechanical and electrical engineering, are introduced to the learners. The engineering design process is the main method used by the robotics strand, which also incorporates

computational thinking. The following are the ideas and abilities taught to learners: how to develop rational procedures that robots can follow, simple mechanical systems including links, gears, and pulleys, and how to design basic electric circuits.

Internet and e-Communication: The internet and e-communication skills strand equips learners with methods for engaging securely on online and offline platforms, the security of digital identity, safety when using digital platforms and technologies, basic internet skills, and how to utilise web browsers to search for information safely.

Application Skills: These are end-user skills that are utilised across many digital platforms. In the Foundation Phase, learners learn about digital platforms, user interfaces, and device functionality. The application skills strand covers the following skills and topics: teaching learners to utilise digital devices, applications, and user interfaces, and to design, edit, and use text and spreadsheets.

According to the draft curriculum (DBE, 2021), the four domains of study are further divided into particular themes in the intermediate phase (Grades 4 through 6):

Algorithms and Coding: Block-based coding platforms are the primary tools for developing programming proficiency. This allows pupils to demonstrate fundamental coding principles in an approachable setting. Integers, strings, variables, and mathematical, relational, and operational operators are among these ideas. Additionally, learners are taught looping techniques, event triggers, broadcasting, and conditional and stacked conditional phrases.

Robotic Skills: Coding and engineering represent two professions that merge within this academic domain. The material builds on the Foundation-Phase knowledge in the Intermediate Phase by introducing block-based platform-coded microcontrollers. Learners use these block-based coding platforms to explore designing logical processes that a robot could execute. Additionally, the learner gains a deeper understanding of fundamental mechanical systems.

Internet and e-Communication Skills: Teaching learners how to engage safely with others online and off is a key component of this curriculum. The fundamental elements of digital gadgets are presented to learners. Along with ideas like copyright violations, piracy, and copyright, learners receive instruction on electronic citizenship and secure browsing habits. Digitisation, cloud computing, and internet communication are among the other subjects included in the C&R curriculum.

Application Skills: At the intermediate level, learners use tools that enhance their electronic display, mathematical, language, and graphic skills. Learners are introduced to tools that require specific end-user knowledge, such as database, display, language-modifying, digital-modifying, and computer-assisted sketching tools.

The subjects taught in the Senior Phase (Grades 7 through 9) are divided into the following four study areas, per the draft curriculum (DBE, 2021):

- Algorithms and Coding: During the Senior Phase, line-based programs builds proficiency in programming. Learners are introduced to line-based coding through a mixed programming platform that combines block-based and line-based coding.
- Syntax-free programming is possible on this hybrid platform, which helps learners concentrate on the ideas rather than the specifics. These notions expand upon the insights gained in the intermediate phases. For example, more advanced instruction is given on looping systems, contingent and layered conditional phrases, mathematical operations, logic, and relationship operators. There is an introduction to fresh ideas such as fact tables, logical gates, and flowcharts. Variables, integers, floats, and lists are all taught to learners. The concepts of operations, parameter passing, and computing libraries are presented to learners.
- Robotic Skills: The knowledge in this field subject matter expands upon the abilities covered in the Intermediate phase. In the Senior Phase, microcontrollers are configured using line-based frameworks rather than the block-based platforms used in the Intermediate phase. Learners learn how to use hybrid and line-based programs to design rational processing stages. The input and output microcontroller elements, as well as mechanical systems with pulleys, gears, and links, are introduced to learners.
- Internet and e-Communication Skills: Security concerns like malware, viruses, and authentication procedures are taught in this field of study. Learners study the applications of machine learning, big data, virtual and simulated reality, and the Internet of Things. Strategies for handling data are presented to the learners. Security and the use of online platforms are also addressed.
- Application Skills: End-user skills involving the usage of apps that include data evaluation and webpage construction are introduced in the Senior Phase. Learners also learn more about HTML while strengthening their spreadsheet application abilities.

Table 2.4(b)

Key Differences in C&R Skills Across Grades

Study Area/Phase	Foundation Phase (R-3)	Intermediate Phase (4-6)	Senior Phase (7-9)
Pattern Recognition & Problem-Solving	Basic identification of patterns in objects and shapes; simple problem-solving using grids and symbols	Develop analysis skills for more complex patterns; introduce computational thinking	Apply advanced pattern analysis; identify complex recurrences and changes in data and designs
Algorithms & Coding	Hands-on block-based coding; basic problem-solving concepts	Block-based coding; learn variables, operators, loops, and conditional statements	Hybrid/block and line-based coding; advanced logic, flowcharts, variables, data structures

Robotics Skills	Introduce simple circuits, gears, pulleys, and mechanical systems	Expand on microcontrollers; design simple robot procedures; deepen mechanical understanding	Line-based programming; configure microcontrollers; design complex robot procedures; integrate mechanical and electronic systems
Internet & E-communication	Basic digital safety, secure platform use, safe browsing	Digital citizenship; copyright; IoT, cloud computing; secure browsing	Advanced digital security; malware, authentication; machine learning, big data, IoT; data handling
Application Skills	Basic device use: text editing, simple spreadsheets	Use of databases, digital editing, sketching, and enhanced math/graphics tools	Advanced apps for data analysis, webpage design, HTML, spreadsheets

Note. Table created by the author and adapted from Department of Basic Education (DBE), 2022.

The aims of teaching C&R, as outlined in the CAPS (Department of Basic Education, 2020, p.12), are:

To inspire learners to think critically and creatively by applying computer-based skills to make informed decisions and solve problems. This includes encouraging learners to analyse, organise, synthesise, and evaluate information in a deliberate and reflective manner. According to Aydoğdu and Turan (2022), C&R supports the development of novel thought processes and new modes of expression, enabling learners to conceptualise and communicate ideas in more sophisticated ways.

A further objective of C&R is to ensure that learners acquire the competencies necessary to communicate effectively using optical, automated, and symbolic forms of language across multiple modes. These communication skills are essential in a technologically advanced society where meaning is increasingly conveyed through diverse and multimodal systems.

In addition, C&R seeks to promote responsibility towards the wellbeing of others and the environment. Through engagement with coding, robotics, science, and technology, learners are equipped to become adaptable, competent individuals capable of functioning in a dynamic and continuously evolving global workplace. As Canpolat et al. (2023) assert, participation in C&R strengthens a range of higher-order thinking skills, including problem-solving, critical thinking, computational thinking, and innovative thinking. Higher-order thinking represents a complex cognitive process that individuals draw upon when addressing unfamiliar or challenging problems.

Moreover, linguistic proficiency is closely linked to the development of higher-order cognitive abilities. Learners must be effective communicators to comprehend complex issues, engage in critical analysis, and generate original solutions. Such linguistic and cognitive

integration is fostered through engagement in C&R activities, which encourage learners to articulate ideas, reason logically, and express creativity (Söylemez, 2018).

The policy architecture described in this section, grounded in the DBE's (2021; 2022) CAPS documentation and Liebenberg's (2022) analysis of the phased rollout, establishes the formal aspirations of C&R implementation in South Africa. However, this body of official literature constitutes a description of policy intent rather than a theory of policy realisation. The seminal work of Fullan (1993; 2001) which forms a cornerstone of this study's theoretical framework warns that the gap between policy mandate and classroom practice is precisely where educational reform fails or succeeds. Supporting scholarship by Haque and David (2022) on curriculum implementation in private school settings, and by McNulty (2022) on pedagogical approaches, further illustrates that the conditions required for successful implementation are rarely present uniformly across schooling systems. Critically, none of the policy documents reviewed adequately accounts for the differential impact of the quintile system on C&R implementation readiness a silence that is politically and pedagogically significant. This study addresses that silence directly by situating teachers' implementation experiences within the quintile context, using the ADCM to theorise how diffusion of the C&R curriculum mandate is mediated, obstructed, and ultimately adapted by teachers according to their school's socioeconomic position.

2.5 Teachers' Attitudes and Perceptions of C&R

Teachers' attitudes and perceptions of C&R are intertwined, as teachers' attitudes will influence how they perceive these subjects. Teachers' attitudes and perceptions of C&R have not been widely explored in South Africa due to its being in its pilot implementation stage; hence, most of the literature examined in this study on teachers' attitudes and understanding of C&R, which are necessary for its proper implementation and future curriculum guidance, is international. According to Schina et al. (2020), teachers have a positive perception of C&R and believe that it will prepare learners to develop 21st-century skills. Teachers also perceive C&R as a skill that will boost learners' lifelong learning, problem-solving, and computational thinking skills (Khanlari & Kiaie, 2015), as noted by Theodoropoulos et al. (2017), who reported that teachers perceive C&R as a means to improve learners' creativity, collaboration, and problem-solving skills. Adler & Kim (2018) found that any C&R workshop, regardless of its duration, led teachers to change their perceptions of C&R and, consequently, adopt a positive attitude towards it. The study further indicated that teachers can shift their negative perceptions of C&R to a positive attitude, even when they start training with negative attitudes.

While many studies allude to the latter statements, emphasising teachers' positive perceptions of C&R, there have also been negative perceptions of the subject (Negrini, 2020). Teachers lack motivation to teach C&R because they believe it is too difficult to teach. This acts as a barrier to the proper implementation of C&R in the classroom (Alcalde & Ortega-Rulperez, 2022). According to Kalogiannakis and Papadakis (2017), negative perceptions of teachers stem primarily from the barriers they face when implementing C&R in schools. These barriers, as alluded to by Papadakis and Orfanakis (2017), range from a lack of knowledge of C&R to a lack of assistance from governing bodies to a fear of using

technology due to a lack of ICT training. The fear of using digital technology further undermines teachers' self-confidence when teaching C&R, as many have very little or no prior knowledge of digital skills (Negrini, 2020).

According to Papadakos and Orfanakis (2016), teachers' perceptions and attitudes towards implementing C&R can either enhance or hinder its effective implementation, while Tang et al. (2020) contend that a lack of training and digital technological infrastructure contributes to teachers' negative perceptions of implementing C&R. Tang et al. (2020) further argue that teachers lack the technical competencies to implement C&R, which poses a challenge to its successful implementation. Furthermore, the teaching of C&R is intricate, as it involves programming and algorithmic constructs that, in turn, require abstract thinking (Bati et al., 2014). Teachers who struggle with these concepts may develop a negative attitude towards C&R, which, in turn, contributes to a negative overall perception of it. According to Negrini (2020), some teachers view C&R negatively because they are concerned that children are already inundated with technology at home, and that implementing it in the school's curriculum may result in the over use of technology. Hence, the study further suggests that C&R should focus on developing learners' transversal skills so that technology is used more intellectually and actively. (Negrini, 2020) further asserts that teachers feel that learners need to be taught skills that focus more on social skills than on technological skills, as most of them are already attached to their tablets and other technological devices daily.

The leading studies in this field as presented by Kalogiannakis and Papadakis (2017), Schina et al. (2020), and Papadakis and Orfanakis (2017) collectively establish that teacher attitudes towards C&R are dynamically shaped by barriers to implementation rather than being fixed cognitive traits. Rogers' (2003) Diffusion of Innovation Theory provides the foundational theoretical lens for understanding attitude as a function of perceived relative advantage, compatibility, and complexity of an innovation. Supporting contextual studies, including Alcalde and Ortega-Rulperez (2022), Tang et al. (2020), and Negrini (2020), extend this framework to include the role of training adequacy and institutional support in attitude formation. However, this body of literature shares a critical limitation: it treats teacher attitude as a dependent variable shaped by external conditions, without examining how teachers themselves as active, reasoning professionals negotiate, resist, and reframe their attitudes in response to contextual demands. Furthermore, South African-specific attitudinal research on C&R remains largely absent, leaving open the question of how attitudes are shaped by the distinctive conditions of post-apartheid public schooling: the quintile system, overcrowded classrooms, the legacy of digital exclusion, and teachers' pre-service training gap. This study contributes to that missing South African scholarship and, through the ADCM framework, repositions teacher attitude not as a barrier to be overcome but as a meaning-laden response to institutional conditions, one that has important implications for how professional development should be designed and delivered.

2.6 The Effect of Professional Development Programmes on C&R

Professional development, as explained by Little (1987, p 491), is "any activity that is intended partly or primarily to prepare paid staff members for improved performance in present or future roles in the school districts". Teachers' confidence levels increase as they attend professional development and training for C&R; however, the training provided must be effective for them to effectively implement what they have learnt during professional development training in their classrooms (Chalmers, 2018). According to Savard and Highfeld (2015), professional

development training in C&R is effective when it is engaging and collaborative. Savard and Highfeld (2015) further noted that effective training activities lead not only to greater learner enthusiasm and teacher participation but also to the development of their overall social skills.

The rapid worldwide emergence of the teaching of C&R has created a need for effective teacher training through professional development. Effective professional development activities require training teachers not only to have a strong grasp of subject content but also a sufficient understanding of pedagogy and technological knowledge, including robotics (Mishra & Koehler, 2006). According to Mason and Rich (2019), the professional development activities offered to primary school teachers are short-term and focus mainly on developing teachers' coding skills and robotics knowledge rather than their pedagogical knowledge. Teachers require development in integrating coding technologies into their instruction. For example, even though teachers understand what abstraction is, they need assistance and guidance on how to teach abstraction to their learners (Giannakos et al., 2015). Hence, effective professional development training is an integral way to support teachers in teaching C&R to learners. Studies conducted by Halmers (2018), Jaipal-Jamani & Angeli (2017), Mason & Rich (2019), and Taylor (2021) all emphasise the need for professional development activities that are effective, hands-on, and provide opportunities for teachers to reflect on lessons and their overall pedagogical knowledge.

The European Union is very clear that schools must provide effective teacher training that develops digital skills, such as C&R, in the classroom (Committee on Industry, Research, and Energy, 2019). According to Abdelghani-Kassem et al. (2016), the effectiveness of teacher training largely depends on the requirements at the end of the training session. These requirements may involve teachers completing an assignment, project, or practice session, which will be used to demonstrate what they have learnt and, hence, how effective their training session was (Abdelghani-Kassem et al., 2016).

The effectiveness of teacher training programmes also depends on the duration of the training session. Short-duration training sessions may hinder the proper unpacking of objectives; however, studies by Daviset et al. (2015) found that, despite engaging in only a three-hour training session, teachers were satisfied with the outcome and viewed it positively. Similarly, studies conducted by Caballero-Gonzalez and Munoz-Repiso (2017) concluded that teachers responded enthusiastically to their one-day training session on educational Robotics. The effectiveness of the programmes, however, cannot be fully determined, as the training sessions did not require participants to report back or engage in a project showcasing what they had learnt. The facilitator also determines the level of effectiveness of the training sessions. The facilitator should possess expert knowledge in the field, and if not, experts in the field must be invited to assist with the training session (Esteve-Gonzalez et al., 2020).

2.7 Teachers' Challenges and the Support Required for the Implementation of C&R.

According to Jantjies (2019), the South African Minister of Basic Education, Angie Motshekga, revealed that the budget for the nine provincial education departments was R281.2 billion, with the implementation of C&R deemed a priority. However, schools in South Africa need to overcome certain challenges before successfully implementing C&R, as maintained by Jantjies (2019). Schools need computers and other digital technologies to support both online and offline use. The inadequate supply of technological tools is mainly due to their high cost (Buselli et al.,

2018). EdTech has implemented initiatives to provide smartboards and paperless classrooms to achieve the goal of integrating digital technology for C&R (Lesufi, 2015). The movement of smart board schooling system initiatives uses smartboards and internet-connected mobile devices to enhance the teaching and learning experiences. The Department of Education aimed to launch the initiative in all Gauteng townships and rural schools by 2018, with an anticipated cost of 17 million (Lesufi, 2015). Funds were allocated by the Department of Education's budget system in 2019 for smartboards, e-content development, software upgrades, educator training, and broadband infrastructure (Motshekga, 2019). The aim was to have classes ready to implement C&R; however, these resources must be properly maintained and managed. schools must have a sustainable financial plan for maintaining the hardware. According to Jones (2021), maintaining hardware is a challenge for public schools in South Africa, as 380 schools still lack water and 3 392 schools still use pit latrines. These schools lack funds for basic needs, as mentioned above, let alone funds to purchase and maintain hardware for C&R.

Coupled with the high maintenance of hardware is the high cost of data. The high cost of data poses a challenge due to its exorbitant price rate when compared to other African countries (Liebenburg, 2022). The implementation of C&R, according to the DBE (2021), requires internet access, which means the school must have data connectivity. This is necessary because the industry environment is ever-changing, with new trends and advancements, and because internet access is required to print, download, and access relevant, up-to-date material (DBE, 2021). As Liebenburg (2022) stated, if we expect South Africa to implement C&R on a digital platform successfully, our first step is to reduce the cost of internet access.

According to Jantjies (2019), the safety and security of computers and other technological equipment used for C&R also pose a challenge in South Africa. Janjies (2019) further asserts that this is due to the high crime rate in South Africa and the lack of funding to properly secure the equipment required for implementing C&R in the classroom. Vandals and burglaries are common in South African schools due to inadequate safety precautions and poor infrastructure upkeep (Amnesty International, 2020). The South African Police department denounced the ongoing violent criminal episodes that take place on school property, as this adversely affects the learning process of the (Amnesty International, 2020). Schools must be properly secured to prevent unauthorised access and create an appropriate learning environment. The lack of teacher training in utilising technology in the teaching and learning process hinders the implementation of C&R (Charbonneau et al., 2016). Consequently, many teachers experience panic, fear, and cynicism about the use of technology in the classroom, which may contribute to their negative attitude towards implementing C&R (MacDonald et al., 2020). School principals reported that newly appointed teachers entering the teaching profession lack sufficient material or pedagogical expertise (Amnesty International, 2020). This is a result of their preservice training, which places too much emphasis on subject information while failing to adequately focus on the practical pedagogical skills necessary to educate children effectively (Amnesty International, 2020). Consequently, school administrators claim that newly appointed teachers need comprehensive job training (Amnesty International, 2020). According to Reinoso et al. (2019), teachers require training and support to teach C&R in classrooms. This training must be adapted not only to meet learners' needs but also to meet teachers' needs. Reinoso et al. (2019) suggest that training must be a continuous process, as teachers are key players in implementing C&R in the classroom. In this regard, Jantjies (2019) highlights that continuous teacher training is vital for introducing novel approaches to teaching and learning C&R.

The lack of didactic materials that teachers need to plan and design C&R activities poses a challenge to the effective implementation of the subject in schools (Khanlari & Kiaie, 2015). Didactic materials enable teachers to design C&R activities aligned with their learners' learning objectives, starting with pre-existing activities they can modify to save time when creating instructional materials (Papadakis et al., 2021). Hence, a teacher community that provides support, guidance, and didactic resources from an educational specialist will be beneficial. The teacher community should not only focus on C&R theory but also provide teachers with pre-planned, established training and didactic materials, as well as tools for designing open-ended activities with their learners (Papadakis et al., 2021).

The education system in South Africa poses a challenge to the implementation of C&R in the classroom. The South African education system is regarded as being one of the most unequal in the world due to its historical roots in apartheid (Spaull, 2015). In public schools, the learner-to-teacher ratio is an astonishing 40:1 (DBE, 2015); however, some schools exceed this ratio. The results of overcrowded classrooms and underqualified teachers are evident according to the most recent Trends in International Mathematics and Science Study (TIMSS) which are as follows; South African Grade 4 and Grade 8 Mathematics learners performed amongst the three lowest countries globally, with only 25% of learners at no – fee paying public schools attaining the lowest possible standard (Mullis et al., 2020). The large classroom sizes, coupled with untrained teachers and a lack of technological resources, further hinder the effective implementation of C&R in the classroom (Hart, 2023). Overcrowded classes are a barrier to teaching C&R in many schools in SA.

2.8 Best-Practice Methods of Teaching C&R.

The concept of 'best practice' in education carries an implicit universalism, a claim that particular methods are generalisable across diverse contexts. When applied to C&R teaching in South Africa, this universalism must be interrogated carefully. The best-practice methods identified in the literature that follows were largely developed in well-resourced, technologically equipped educational environments. Whether they represent transferable models or context-bound ideals for South African Foundation Phase teachers is a question this study is positioned to address through the ADCM's emphasis on contextual adaptation as a necessary stage in curriculum adoption.

A study conducted by Alimisis et al. (2017) emphasised the importance of collaboration among teachers throughout training programmes as a best practice method, while the study by Cesaretti et al. (2019) reiterated the value of collaboration, in which teacher trainees share ideas, compare alternative outcomes and solutions to solve problems. Another best practice for teacher training, as identified in a study by Balogh et al. (2022), is that teachers should develop their own training materials, test them with their learners, and share them with other teachers. Cross et al. (2016) concur, suggesting that teachers should design their own activities during their training time and implement them in their classes.

A study conducted by Buselli et al. (2018) found that teacher training in didactic, pedagogical, and learning theories is a best-practice methodology. Negrini (2020) argues that there is a deficit of C&R didactic materials available to teachers, hence they tend to view C&R as difficult to teach. Teachers were instructed to develop their own didactic projects that went beyond the use of robots. In another study conducted by Cesaretti et al. (2019), teachers were trained in pedagogical methodologies and innovative didactic methods as best practices for training in

C&R. Kucuk and Sisman (2018) concur by recommending integrating pedagogical and didactic content into teacher training. Didactic materials should be included in teacher training.

Darling-Hammond et al. (2020) recommend that teachers provide feedback on the lesson plan developed during the training sessions. Facilitators of C&R workshops should provide ongoing support to teachers beyond training sessions. As Negrini (2020) asserts, facilitators should also be invited to observe teachers in the classroom as they implement what they have learnt in the training sessions, as this will give the facilitators an idea of how effective the training was. A best-practice method currently being implemented in Switzerland is the formation of the robotic teacher community (ROTECO), which was established to support teachers implementing C&R activities and to promote their presence in the classroom (Assaf et al., 2022). This is a web platform designed to help teachers receive support, share experiences, and access instructional resources to promote the use of C&R in the classroom. The site is designed to allow users to submit activities, connect with peers, download resources, and most importantly, stay up to date on the latest C&R events, research, and courses (Assaf et al., 2022).

The best-practice literature in this section coalesces around a collaborative, reflective, and resource-generative model of C&R teaching, with Alimisis et al. (2017), Balogh et al. (2022), and Darling-Hammond et al. (2020) representing the leading voices in articulating what high-quality C&R pedagogy requires. The Swiss ROTECO platform (Assaf et al., 2022) represents an innovative structural model that externalises best practice through a community of practice framework. These are valuable contributions. However, their critical limitation is that they are almost entirely produced in resource-sufficient contexts: Switzerland, Europe, and North America. They assume stable internet connectivity, access to robotics kits, and willing institutional support conditions that the majority of participants in this study did not have. The best-practice literature therefore functions, in the South African context, not as a prescription but as a benchmark against which the realities documented in this study can be measured and critiqued. By examining how teachers in quintile 2-5 schools develop and share their own adapted practices including unplugged activities, outdoor learning, and cross-curricular integration, this study examines what best practice actually looks like in under-resourced South African classrooms, thereby expanding and contextualising the dominant international literature.

2.9 Why Unplugged C&R?

As a developing country, South Africa must take precautions to avoid falling behind in the 4IR. C&R Unplugged is an effective way to teach C&R, as nearly 16 000 schools in South Africa lack computer labs (Dube, 2020). In addition to the lack of computer labs, there is also a lack of teacher training in C&R, safety and security, technical support, and customised educational materials, further adding to the challenges of teaching C&R in schools (Rivett, 2019). C&R Unplugged can be an effective way to introduce learners to the field. Despite teachers lacking a C&R background, the frequent power outages and load shedding South Africa faces, and the overloaded curriculum, it remains an effective way to introduce C&R to learners. Unplugged Coding employs games or tasks that can be completed offline with tangible materials such as paper, coloured pencils, markers, and pens. It is a more hands-on approach to teaching C&R, with a lot of active play.

C&R Unplugged can be seen as a simpler way to teach C&R in the classroom. Computer programming has a steep learning curve (Govender & Govender, 2021); hence, implementing the C&R curriculum using non-digital techniques, such as C&R Unplugged, may help teachers adopt a positive attitude towards it. C&R require technological equipment and WI-FI connectivity to be effective. C&R Unplugged was designed as a method of teaching C&R without technology so that children can practise the basics of coding, such as loops, units, commands, and algorithms (Canbeldek, 2023). C&R Unplugged activities utilises basic algorithm concepts which are as follows: units which is an expression that denotes any activity adhered to in the algorithm, a command is an order to carry out a unit or loop in the algorithm, a loop is associated with operations carried out using specific sequential values, a loop is a repetitive structure in an algorithm that replicates particular blocks for a specific number of times (Vatansever, 2023).

The current tangible C&R Unplugged activity used by nearly 30 000 learners in South Africa is called TANKS (Willemse, 2019). Tanks was developed by a computer science honours student in 2017 (Batteson, 2017). Using Tanks, learners can create instructions using physical tokens, personalised puzzle pieces, and visual recognition, all conducted in a mobile app (Willemse, 2019). Tanks uses tokens that instruct the images in a mobile app to move in a certain direction, and it has 35 levels that increase in complexity. There is an initial, simple, sequential stage in which simple commands are followed, such as move forward, move backwards, turn right, and turn left. As the levels increase, more complex commands are introduced, such as loops and nested loops. Loops are the repeat command. According to Greyling (2023), Tanks, as unplugged C&R, is very meaningful, as it allows learners to collaborate, encourages problem-solving, helps them handle conflict, and lets them have lots of fun while doing so.

Unplugged C&R affect computational skills. A study by Tonbuloglu and Tonbuloglu (2022) examined the effect of unplugged C&R on learners' computational thinking skills. The study comprised 115 Grade 5 learners who trained in unplugged Coding. Learners' computational thinking skills were examined at the beginning and end of the study, during which learners were taught unplugged C&R activities. An analysis of daily observations of data collected throughout the study revealed the following: learners demonstrated higher motivation, increased classroom involvement, and improvements in critical thinking, creativity, algorithmic thinking, and their ability to work as a team with other learners. Hence, the above study concludes that C&R Unplugged indeed has a positive influence on learners' computational skills.

2.10 C&R in STEM Education

STEM education refers to the integration of Science, Technology, Engineering, and Mathematics into a unified learning experience, whether in a single lesson, unit, or class that emphasises the interrelationships among these disciplines and focuses on solving real-world problems (Falloon et al., 2020). According to Norman (2022), the defining feature of STEM education lies in its interdisciplinary nature, which promotes a holistic exploration of concepts and fosters connections across diverse scientific domains. This interdisciplinary engagement is facilitated through collaborative group projects that enhance learners' cooperative skills and through the deliberate application of prior knowledge and experiences (Norman, 2022). Within this framework, C&R can serve as a powerful mediating tool to support teaching and learning processes in STEM education (Atman Uslu et al., 2022). Furthermore, the STEM disciplines provide a platform for cultivating 21st-century skills aligned with the

demands of the Fourth Industrial Revolution (4IR) (Twin Science, 2020). Empirical evidence also suggests that STEM education positively influences learners' aspirations, behaviours, and technological competencies (Asiroglu & Akran, 2018).

C&R have been reported to have a positive effect on learners' STEM education (Anwar et al., 2019) because they can better understand the intricate principles of STEM subjects through these approaches rather than through mundane, passive teaching (Mohamed et al., 2021). While the literature reveals positive effects of integrating C&R in STEM teaching from the perspective of learners, teachers tend to struggle with teaching STEM subjects using these tools. Studies attribute this to teachers' negative attitudes, inadequate didactic training, and insufficient scientific knowledge. According to García-Carrillo et al. (2021), teachers' negative attitude towards STEM subjects is mainly due to a lack of conceptual and procedural knowledge, a lack of personal and professional experience in effectively teaching C&R using STEM subjects, and misconceptions about STEM subjects. A common misconception is that technology and engineering are optional subjects taught in school, and that technology is often limited to computing-related tasks such as word processing (Texas Education Agency, 2021). Moreover, there is a misconception that STEM education only relates to subjects that align with workforce requirements. Another false belief is that teachers who specialise in one area, like math or C&R, are not capable of effectively teaching other STEM subjects, which goes against the interdisciplinary nature of STEM education (Ansberry & Morgan, 2019).

As contended by García-Carrillo et al. (2021), teachers can utilise C&R to foster creativity among learners by engaging them in projects that enhance their critical thinking skills, with the ultimate goal of enabling learners to solve problems in STEM subjects. Teachers should consistently foster a spirit of inquiry and creativity among their learners (Zhan & Niu, 2023). In addition, teachers must effectively construct diverse and interdisciplinary perspectives into the C&R curriculum. In doing so, learners can work together on projects, gaining a deeper understanding by stimulating ideas and situations that exist outside the classroom and the immediate community, and within the larger field of STEM education, utilising C&R (Dare et al., 2021).

2.11 Nature Deficit in Learners

C&R require learners to utilise digital technology. Investigations into digital technologies are regularly conducted across a variety of sectors, as the broad spectrum of information accessible online is reflected in the diverse content of online activities. The effects of digital technologies on children's mental and physical development have been the subject of significant debate. Furthermore, the anxiety that arises when kids are separated from their devices, as neuroscience frequently reports, negatively impacts sleep, recall, reading comprehension, focus, and face-to-face communication (Markin, 2018).

According to Puig and Casas (2014), recent developments in modern societies have been marked by extensive urbanisation, which has led to the reduction and deterioration of natural spaces, creating increasingly urbanised surroundings where children's connection to nature becomes more complicated and remote. In addition to this hyper-urban model of cities, there is the presence of the virtual space, the expansion of which has caused significant changes to how children relate to their environment (Ibáñez Ayuso et al., 2023). The combination of both phenomena – that

is, the proliferation of information technology alongside the expansion of urban construction – reinforces what Louv (2005) refers to as the "nature deficit," which is maintained by social dynamics primarily mediated by technology and taking place in urban settings. Consequently, a great deal of time spent on digital and virtual settings, C&R affects the way children perceive things, patterns, and behaviours, which has a big impact on their conduct and, in turn, on the fundamental processes of learning.

Adams and Beauchamp (2021) emphasise the importance of integrating children and nature. To understand the perceptions, emotions, and sensations that result from children's interactions with nature, these researchers conducted several experiential activities in their study (Gerwin et al., 2018). Their findings were that children felt peaceful, content, free, and relaxed, highlighting the chance that natural settings offer for reflective exercises. Gerwin et al. (2018) further contend that children's temporal consciousness is influenced by nature, thereby illustrating its liberating essence. While C&R are important, overexposure to them, alongside other technological devices, has the potential to result in a nature deficit in children. According to Radesky and Christakis (2016), children presently spend their entire lives immersed in digital technology, and studies have repeatedly demonstrated that its use is increasing amongst children. LeBourgeois et al. (2017) argue that children who are exposed to technology often desire to use it constantly, which can lead to a dangerous cycle. LeBourgeois et al. (2017) further highlight the impact of technological devices on young children, a concern since they interfere with the interaction between parents and children, which is essential for their psychological and intellectual growth. A later bedtime is associated with less restful sleep, suggesting a negative correlation between visual media use and sleep quality. While digital technology has the potential to improve social interaction, imaginative thinking, and early childhood development, LeBourgeois et al. (2017) recommend that parents be vigilant about what their children are doing online and support their learning.

2.12 C&R Curriculum that is Inclusive and Accessible

Inclusion and accessibility are critical components of a fair education system. In South Africa's C&R curriculum, inclusion refers to the creation of a learning environment which embraces diversity, promotes equal opportunities, and supports learners' diverse needs (Moodley, 2020). At the same time, accessibility refers to the design and implementation of instructional materials, devices, and activities that support learners with varying abilities and requirements (Seale, 2020). According to the DBE (2020), the C&R curriculum aims to offer all learners, regardless of background or competencies, the opportunity to engage with C&R, thereby encouraging technological understanding and computational skills while remaining inclusive and accessible. However, despite the claims made in the C&R curriculum, numerous C&R programs continue to be inaccessible to underrepresented learners, including individuals with impairments and learners from low-income households (Gomez and Sanchez, 2020). Notably, McKinsey & Company (2021) emphasises that the successful execution of C&R can enhance engagement among historically underrepresented populations, including females and learners with impairments.

Research consistently shows that diversity and representation are important in C&R education, and learners from marginalised communities displayed greater enthusiasm to learn when they perceived their diversity as integrated into the C&R curriculum (Gomez and Sanchez, 2020). Similarly, Walton and Engelbrecht (2022) emphasised the need for inclusive and accessible C&R education, highlighting the value of a greater

variety of instructors and mentorship. Despite the significance of inclusivity and accessibility in the C&R curriculum, many schools still lack it (Bhagat et al., 2020).

2.12.1 Accessibility and Inclusive Design

An inclusive design of the C&R curriculum is crucial to ensure it is available to all learners, irrespective of their abilities and backgrounds (Mladenovic et al., 2020). Mladenovic et al. (2020) conducted a qualitative study on the use of accessible robotics kits by learners with impairments, emphasising the importance of more inclusive design methods. Similarly, Bhagat et al. (2020) stressed the need for inclusive coding languages and tools for learners with impaired vision. Given the importance of inclusive design, most C&R programs still use inaccessible materials and methods, posing challenges for learners with impairments (Kao & Lin, 2020). Teachers play an important role in overcoming these hurdles by adjusting lesson plans, incorporating assistive technologies, and creating an inclusive classroom climate. The degree of inclusion is often determined by teacher preparedness, resource availability, and pedagogical tactics. Incorporating accessible and inclusive design principles fosters equity while also improving problem-solving and computational thinking for all learners.

Reflecting on the relevance of inclusive design, research suggests that professional development and focused teacher training are required to effectively deploy an inclusive C&R curriculum (Jones, 2021). Teachers who receive continual development in adaptive teaching practices and new technologies are better prepared to meet the needs of diverse learners. Additionally, cooperation among teachers, department officials, and subject advisers can result in a more diverse and inclusive design, ensuring that accessibility is not a secondary consideration but a fundamental principle. Schools may provide a more equitable and interactive learning experience by prioritising both teacher preparedness and systemic support, enabling all learners to participate in computational thinking and robotics activities fully.

According to studies by Kao and Lin (2020), teacher development and support are critical for the successful implementation of an inclusive and accessible C&R curriculum. Kao and Lin (2020) further found that teachers who received inclusive training reported higher levels of trust and expertise in teaching learners with diverse learning abilities. Similarly, Magaldi and Berler (2020) found that an inclusive C&R curriculum requires ongoing teacher support and funding to ensure its long-term viability. Notwithstanding the significance of teacher development and support, there remains a lack of the necessary skills and tools to adequately instruct diverse learners (Walton & Engelbrecht, 2022). The findings of this literature review show that many C&R programs are not inclusive or accessible to marginalised pupils. Despite the importance of diversity and representation, accessible and inclusive curriculum, and teacher development and assistance, many programmes still lack these components. This reinforces the idea that C&R are reserved solely for privileged learners, leaving underprivileged learners at a disadvantage in these disciplines. As a result, we must improve C&R education to make it more inclusive and accessible. This can be achieved by reforming the C&R curriculum to make it more inclusive and accessible to all learners, irrespective of historical background or ability.

2.13 Conclusion

This chapter provided an in-depth review of the literature, critically examining the theoretical, conceptual, and policy frameworks that drive the implementation of the C&R curriculum in South African primary schools, with a focus on the Pinetown District. The first assumption is universalism, the implicit claim that findings generated in European, North American, and East Asian educational contexts are transferable to the South African public school setting. This assumption fails to account for the quintile system, the apartheid-rooted inequality of resource distribution, the specific pre-service training landscape of South African teachers, and the socioeconomic realities of the Pinetown District. This study is philosophically committed to contextual specificity: its findings are generated from and speak to a particular educational context, and the ADCM is proposed as a context-sensitive theoretical framework rather than a universal model. The second assumption is a deficit orientation, the tendency to frame teacher challenges as deficits to be remedied (lack of training, lack of resources, lack of confidence) rather than as responses to structural conditions that warrant systemic critique. This study adopts a position of epistemological generosity towards its participants: it examines how teachers develop adaptive strategies, construct contextually relevant pedagogies, and exercise professional agency under conditions of constraint, not as exceptional or heroic behaviour but as the ordinary and under theorised work of teaching in an unequal system.
The third assumption is linearity, the expectation, embedded in Rogers' (2003) Diffusion of Innovation Theory, that curriculum adoption follows a predictable sequence from awareness through adoption to implementation. The literature reviewed here offers limited insight into what happens when that sequence breaks down, when teachers are simultaneously asked to know, adopt, and adapt a curriculum they have had no input in designing. Fullan's (1993) Theory of Deep Change provides a more realistic theoretical account, insisting that meaningful curriculum reform requires personal transformation, institutional support, and collaborative sense-making not compliance with a mandated rollout schedule. The ADCM, by integrating both theories and adding the Adaptation Stage, proposes that South African teachers are already engaged in a theoretically significant process of contextualised curriculum-making, one that the existing literature has not yet named or examined. That is the contribution this study makes. Overall, this chapter provided a theoretical and conceptual foundation for the research design and guided the analysis of teachers' lived experiences, which were explored in the following empirical chapters. By situating the study within both national and global discourses on educational innovation, this chapter laid the groundwork for understanding how teachers navigate, interpret, and implement the C&R curriculum in the dynamic and changing South African educational landscape.

CHAPTER THREE: The Adoption through Deep Change and Diffusion Model (ADCM): A Theoretical Framework for C&R Curriculum Adoption.

3.1 Introduction

The previous chapter outlined a detailed presentation of the literature explored to illustrate the dissemination and implementation of the C&R curriculum policy, to understand teachers' perspectives, attitudes, and challenges in implementing C&R, and to provide some insight into best practices in teaching C&R.

This chapter presents the conceptual framework that underpins the study. The framework served as the foundation for the research, providing both the rationale for the investigation and a structured lens through which the C&R phenomenon was examined. Conceptual frameworks are essential for identifying gaps in current knowledge, as they contextualise the research problem within the existing literature and clarify the study's methodological orientation (Paradis et al., 2020). As Maxwell (2013) asserts, a conceptual framework is intended to address two central questions: Why is the research important? and what new insights will the study contribute to the existing body of knowledge?

The conceptual framework for this study is not derived from a single theory but rather the result of integrating two theoretical perspectives. Specifically, Rogers' (2003) Innovation Diffusion Theory (IDT) and Fullan's (1993) Theory of Deep Change were employed as foundational theories. These theories are discussed in detail in the subsequent sections to elucidate their core principles and relevance to the study. Their integration forms the conceptual framework that guided the investigation, offering a comprehensive perspective on how the C&R policy was communicated to, and implemented by, teachers. The framework thus provided the analytical lens through which data were interpreted and the research questions addressed.

3.2 Guiding Theories

The IDT, as premised by Rogers (2003) is that teachers' acceptance and knowledge of a curriculum determines the level of effectiveness of its diffusion, while the Theory of Deep Change, according to Fullan (2004) states that, for deep change to occur (the Deep Change being the diffusion of the C&R curriculum) there must be a deep understanding and deep learning of the phenomena under study. These two theories were combined to form a conceptual framework, which led to the development of a fifth stage to extend the IDT.

The fifth stage represents the new knowledge that this study seeks to contribute to the Innovation Diffusion Theory (IDT). This phase, referred to as the Adaptation Stage, becomes possible through the integration of IDT with the Theory of Deep Change. The Adaptation Stage is grounded in the premise that individual schools will modify the innovation to meet their specific contextual needs. Such adaptation requires a deep change and a thorough understanding of the innovation itself. On this basis, the conceptual framework introduces a new, fifth stage-the Adaptation Stage-which extends the existing IDT model. A more detailed discussion of the IDT follows below.

3.3 Diffusion of Innovation Theory (DOI) - Background of DOI

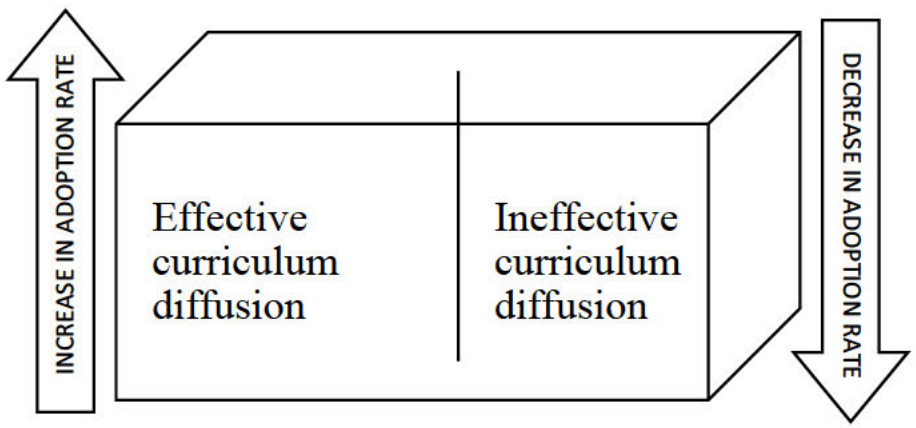
Evertte M Rogers is the sociologist and communication expert credited with developing the idea of Diffusion of Innovation (DOI). The foundations of the DOI Theory can be traced back to agriculture, where researchers began examining farmers' adoption of Iowa State Agricultural Experiment Station hybrid corn in 1928 (Garcia-Aviles, 2020). The DOI Theory was widely adopted by Iowa corn growers by 1940, as the amount of land planted with hybrid corn rose from hundreds to thousands of acres between 1933 and 1939. Ryan and Gross (1943) were the first to introduce a category called adopters and categorise farmers as adopters. Rogers conducted further research and published his ground breaking book, The Diffusion of Innovations, in 1962, which was reprinted in 1971, 1983, 1995, and 2003 (Garcia-Aviles, 2020).

The DOI between and among organisations has piqued the interest of investigators, theorists, and administrators from a wide range of disciplines, particularly Information Technology, Sociology, Education, Public Health, Healthcare, and Organisation Theory (Roger, 2003). Diffusion, according to Rogers (2003), is the process by which an innovation is passed along through certain channels among individuals in a social system. As a result, diffusion is viewed as a unique form of communication in which individuals exchange knowledge to reach an understanding. Diffusion has a distinctive character because the notion in the message is new; hence, some degree of unpredictability is involved. The innovation being diffused in this study is the C&R curriculum, which was recently introduced; therefore, there is a degree of unpredictability, and the diffuser of the innovation is the teacher.

Greenhalgh et al. (2004) conducted a study of the literature on the dissemination and long-term sustainability of innovations, which led to the emergence of thirteen new significant research traditions. Four of these were classified as "Early Diffusion Research" and they are as follows: medical sociology - where comparable theoretical explanations were utilised to explain doctors' clinical behaviour; Communication Studies - which examine the velocity and efficacy of news transmission and improve important variables like the message's delivery technique and intended adopters' experiences with it; rural sociology – Rogers first developed his Seminal Theory in marketing and economics where innovations were usually products or services and the adoption decision was conceptualised as a rational analysis of costs and benefits by the intended adopter. The diffusion of the C&R curriculum, in alignment with early diffusion research as explained above, can be classified under marketing and economics, as well as communication studies. Utilising marketing and economics as an early diffusion research method whereby the product is the C&R curriculum and the services is the teaching of the C&R curriculum provided by teachers, hence the decision to adopt the innovation being the new curriculum will be conceptualised based on the cost and benefits to both the teacher and the learner with focus in this study being the teacher. When the cost of disseminating the C&R curriculum is high, the adoption rate among teachers will be low. When costs are low, adoption rates will be high.

Figure 3.3(a)

An Illustration of the Rate of Adoption of the C&R Curriculum Utilising Early Diffusion Research -Communication Studies

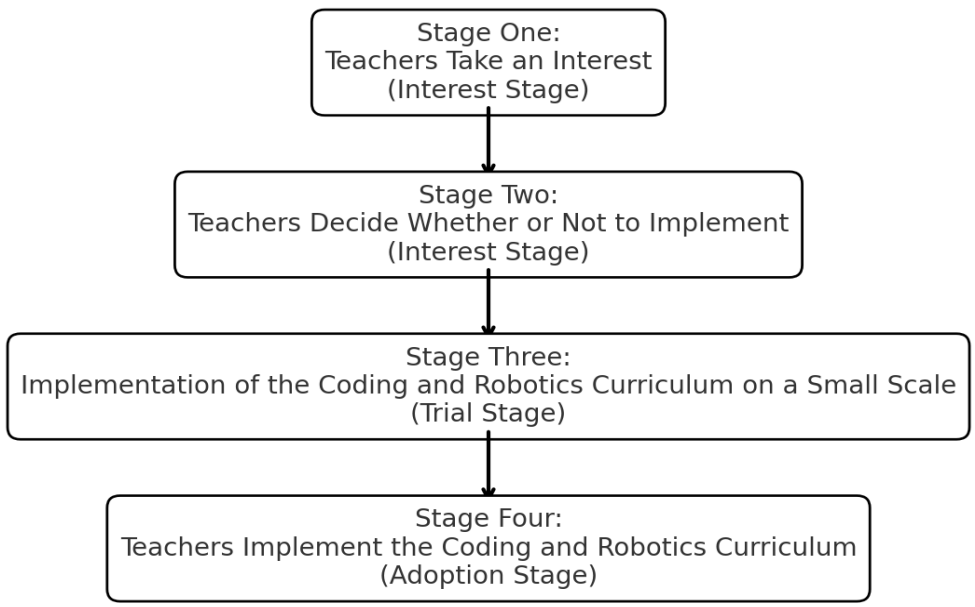


Note: Visual representation created by author, adapted from Rogers (2003).

In classifying the adoption of the C&R curriculum under Communication Studies utilising dissemination and long-term sustainability of innovations conducted by Greenhalgh et al., (2004) the delivery of the C&R curriculum techniques and teachers' experiences with it determines its adoption rate for example, effective curriculum diffusion will result in an increase in the adoption rate by teachers while an ineffective curriculum diffusion will result in a decrease in the rate of adoption by teachers. The IDT, as proposed by Rogers (2003), was intended to comprehend why, how, and at what rate new ideas are spread through the C&R curriculum. An innovation takes time to diffuse throughout a social system; it does not occur immediately. It takes a series of thoughts and deliberations to determine whether to adopt a specific invention (Dearing & Cox, 2018). The primary areas of attention for the IDT are the perceived attributes of technology and the inventiveness of the organisations that implement them.

Figure 3.3(b)

The Four Stages of the Innovation Diffusion Process



Note*:* Visual representation created by author, adapted from Rogers (2003).

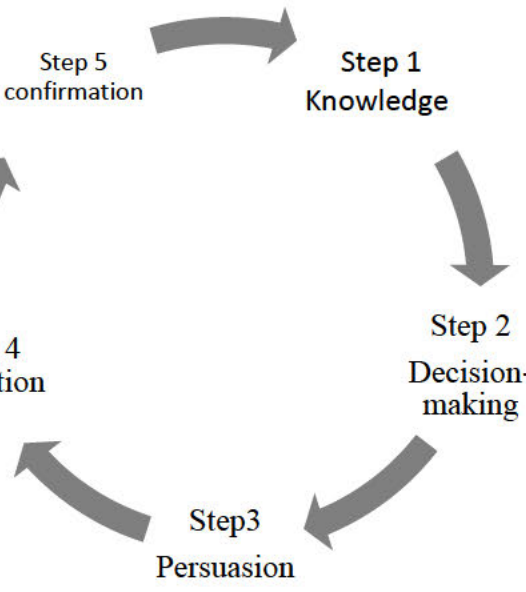
The first stage is the interest stage, where a person begins to learn specific information about the idea; The second stage is the evaluation stage, where a person decides whether to implement the innovation; The third stage is the trial stage, where a person uses the innovation experimentally or on a small scale; the final stage is the adoption stage, where a person implements the innovation continuously and widely. According to Rogers (2003), the adoption stage is further influenced by five characteristics: testing of the C&R curriculum, complexities involved in the implementation of C&R curriculum, integrating organisational operations and knowledge such as the training provided by organisations for implementing the C&R curriculum, the perceived benefit over current technologies and the observability of the innovation's advancement both within the organisation and among competitors. The rate of adoption of the C&R curriculum is predicted by teachers' views of the five characteristics as mentioned above. Hence, the final two stages are very important, as they determine whether or not the innovation will be accepted and adopted.

3.3.1 The Main Objective of the IDT

This study focuses mainly on the adoption stage to analyse the adoption process. Rogers (2003) developed an Innovation Decision Process Model. This model primarily consists of seeking knowledge and processing information, activities that inspire teachers to reduce uncertainties about the benefits and drawbacks of the C&R curriculum. Every teacher or organisational decision-making institution goes through the innovation decision process, which involves learning about the innovation (the C&R curriculum), developing an attitude towards it, deciding whether to accept or reject it, putting the new idea into practice, and having the decision confirmed.

Figure 3.3.1(a)

Five Steps of Conceptualised by Rogers (2003) in the Innovation Decision-Making Process



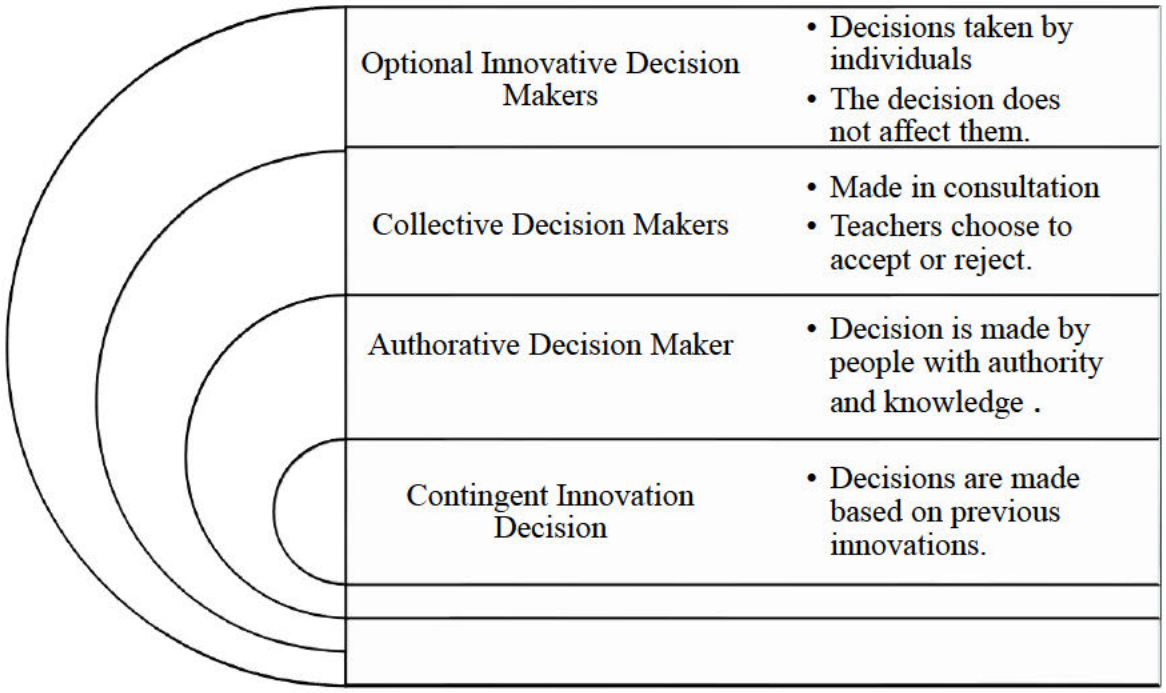
Note: Visual representation created by the author, adapted from Rogers (2003).

The innovation diffusion process, as conceptualised by Rogers (2003), comprises five steps: knowledge, decision-making, persuasion, execution, and confirmation. During the knowledge stage, teachers are curious about the nature of the C&R curriculum and how it operates. Teachers look for innovation-evaluation data during the persuasion and decision stages to help them become less unclear about the anticipated outcomes of the C&R curriculum. The decision step results in either rejection or acceptance, depending on whether using the C&R curriculum to its fullest potential is the most advantageous option. According to Rogers (2003), the extent to which a user alters or modifies an innovation during its adoption and implementation is known as reinvention. As Rogers (2003) asserted, mass media outlets are better at disseminating information about innovations, while interpersonal channels are better at influencing people's attitudes towards new ideas and helping them decide whether to accept or reject them.

Teachers assess the C&R curriculum through interpersonal channels, relying on peers' subjective opinions rather than on professional, scientific study. Their peers act as social role models; hence, teachers tend to emulate their innovative acceptance or non-acceptance of the C&R curriculum. Innovativeness, according to Rogers (2003), is the extent to which a person or another group of adopters adopt new concepts comparatively sooner than the rest of a social system. The rate at which teachers in the education system adopt the C&R curriculum is called the adoption rate. A school's interpersonal and technological structure can help or hinder the spread of the C&R curriculum inside it.

Figure 3.3.1(b)

Categories of Innovative Decisions Created by Rogers (2003)



Note: Visual representation created by author, adapted from Rogers (2003).

Rogers (2003) divides innovative decisions into three categories: (i) Optional innovation decisions, which are those taken by an individual teacher, unaffected by the actions of different system members; (ii) Collective innovation decisions, which are those made by agreement between system members, allowing them to choose whether they will embrace or dismiss the C&R curriculum reform. (iii) Authority innovation, which is the choices on whether to accept or reject an innovation made by a small number of people with authority, status, or technical "know-how" within a system, such as education specialists and subject advisers. According to Rogers (2003), a logical arrangement that includes at least two of the above innovation-decision kinds makes up a fourth category: (iv) Choices about what to accept or reject that may only be made following a previous innovation decision are known as contingent innovation decisions. Hence, the school, as a representation of the social structure, plays a role in disseminating repercussions, or the changes resulting from the acceptance or rejection of the C&R curriculum. According to Rogers (2003), "opinion leaders" are important participants in the process, since their viewpoints will influence others more than anyone else's. Opinion

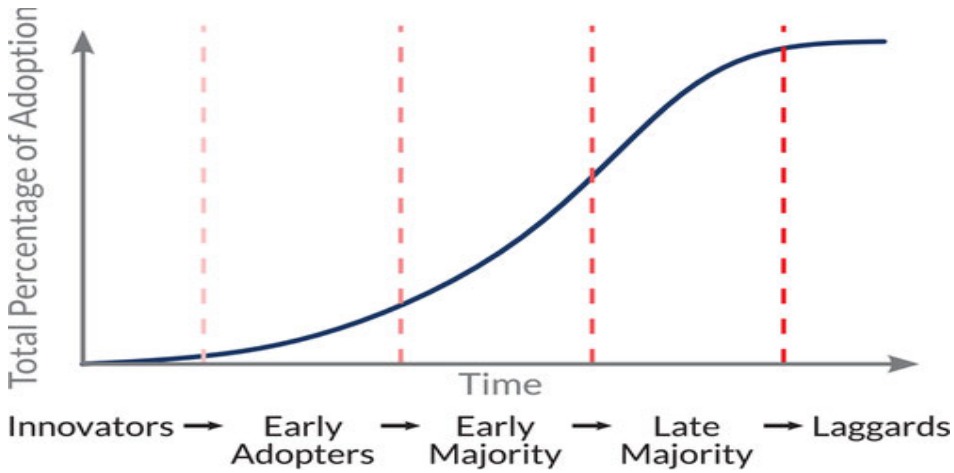
leaders are the teachers who have spearheaded the C&R curriculum at their schools, the teachers who advocate for change and innovation, and the field leaders who have been trained to disseminate the C&R curriculum into schools.

According to Call and Herber (2022), the majority of innovations follow an S-curve pattern of adoption, with the percentage of people adopting an innovation rising over time. The adoption of the innovation usually begins gradually, with a small number of teachers classified as early adopters who learn about, refine, and choose to accept the innovation. In this study, the innovation is the implementation of the C&R curriculum into the classroom. The acceptance of the C&R curriculum will increase as the early majority of teachers come to understand and enjoy the innovation. The pool of potential adopters for an innovation shrinks as it becomes more widely adopted, and the adoption rate drops as late adopters embrace it.

The last stage is when the adoption curve flattens; this occurs as the last potential adopters, such as laggards, adopt the innovation. This study focuses on the early adopters' phase, as the researcher seeks to understand how C&R is diffused to teachers and what their perceptions, attitudes, and understanding of this diffusion are, as these factors influence the effective implementation of the C&R curriculum within the classroom. This study aims to adopt a fifth stage, achieved by combining the two theories to form a conceptual framework. The fifth stage will be known as the adaptation stage.

Figure 3.3.1(c):

An Illustration of the Growth Rate of the Diffusion of C&R



Note*:* Applicability of the Diffusion of Innovation Theory to Accelerate Model-Based Systems Engineering Adaption. *Systems Engineering* (P.2), by Call & Herber, 2022.

The lack of proper diffusion due to weaknesses or competition from other innovations may result in the innovation not being adopted, leading to its failure to diffuse. Therefore, teachers' attitudes towards implementing C&R could influence the diffusion process, especially in the final two stages. As Papadakis and Orfanakis (2016) assert, teachers' attitudes towards implementing C&R can either enhance or hinder its effectiveness.

Teachers' knowledge and acceptance of the policy, as well as its diffusion, are likely to be influenced by how well they are informed and capacitated about it. By using the Theory of Diffusion of Innovation, this study posits that the extent to which teachers understand, interpret, and embrace C&R depends on the nature and quality of the information they receive and, therefore, on the innovation diffusion process. The study is premised on the notion that directives for change do not, in fact, bring about change. Thus, it is critical to mobilise support for an innovation by making information about it available so that change agents (teachers) understand what it is, its benefits, and how to implement it. This study explores how the Department is managing the C&R process.

The corpus of DOI research reveals variations regarding interpersonal style, personality traits, and financial status amongst innovators who adopted innovations earlier and later (Rogers, 2003). In addition to having greater status in society, more opportunities for social advancement, and a commercial rather than subsistence financial perspective, earlier adopters are also more inclined to accept the C&R curriculum than late adopters. In terms of personality traits, early adopters and later adopters are different. Early adopters, in Rogers' opinion, are more empathetic, less dogmatic, more accepting of change, better able to handle uncertainties and risks, have a warmer disposition towards both technological innovations, and are generally more driven to succeed. The adoption of the C&R curriculum at schools can be explained by a variety of factors, such as the communication process between the teacher and the availability of technology information, the teacher's attributes (such as prior experiences), and social system characteristics (such as management support).

The practical ramifications and usefulness of DOI Theory are what make it strong; hence, it can be utilised across a broad range of situations (Atkin & de Paula, 2015). The diffusion process in the model represents the activity required for the C&R curriculum to spread from its initial development to reach a larger number of teachers, regardless of culture, social structure, or demographics. Kapoor et al. (2014) conducted a systematic review and meta-analysis of papers on Rogers' innovation attributes and found that the majority of studies are retrospective and focus primarily on innovation adoption, with little or no attention paid to implementation or postadoption behaviour.

3.3.2 Criticism of the DOI Theory

The DOI Theory was criticised largely for its agrarian approach and its inability to support advances in more technology industries (MacVaugh & Schiavone, 2010). In addition, there were variations in the adoption rates and patterns of innovation diffusion, as users frequently had unfavourable opinions about cutting-edge innovations. The business community also voiced concerns, noting that anyone can be an innovator if their ideas are paired with organisations that are receptive to them (Downs & Mohr, 1976). The decision-making process is more intricate in organisational management than at the individual level. Teachers will view the diffusion of the C&R curriculum differently, depending on their personal experience engaging with it, rather than an organisation intending to diffuse a technological innovation. Organisations are shaped by their policies, procedures, and unwritten norms. It is not always necessary for an innovation to go through several stages of adoption before a person adopts it, as Lyytinen and Damsgaard (2001) contend. Teachers may adopt the C&R curriculum at any stage, provided they believe the technology is worth adopting. Adoptions can occasionally occur in dyadic interactions, making it challenging to pinpoint the stages of adoption. Lyytinen and Damsgaard (2001) further discovered that some laggards possessed greater vision than the innovators identified by DOI Theory. A

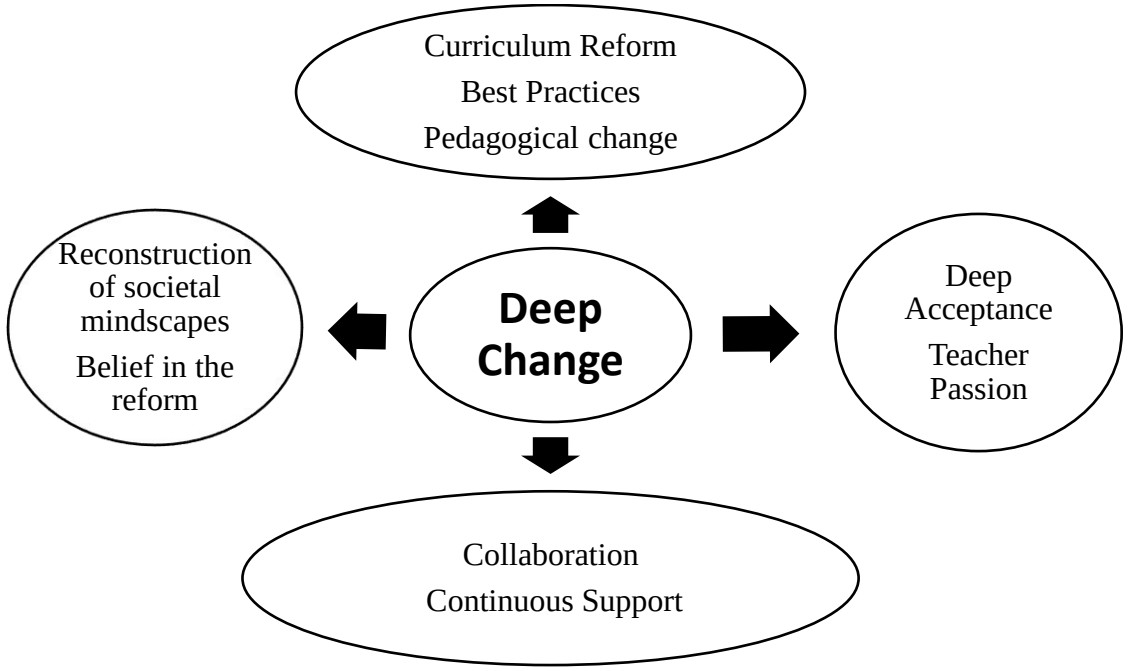
further significant component examined in the DOI studies is the organisation's (in this context, the school's) innovative capacity, which includes the traits of individual leaders and the school's structure. The school's capacity to accept innovative thinking depends on school size, decentralisation, degree of complexity, low formalisation, extensive interpersonal associations, and unconstrained resources. On the other hand, less complexity and greater centralisation during the diffusion process might also facilitate the dissemination and acceptance of the innovation.

Rogers also criticised the narrow, stereotypical manner in which numerous academics have defined the scope and methodology of diffusion as a field of study. He further acknowledged that his theory of innovation diffusion had become overly simplistic over time. He held DOI scholars accountable for their focus on the dependent variable of adoption rather than on the implementation process or the innovation's effects. The assumed qualities of technology as it diffuses play a major role in the DOI Theory adoption paradigm, which opens it to the critique that it is largely dependent on technology. The effective diffusion of the C&R curriculum is influenced by teachers' training, mind-set, and understanding of the C&R curriculum. The actual curriculum, which comprises the technology, is not the main determinant of the diffusion's acceptance.

3.4 Theory of Deep Change

Figure 3.4(a)

Deep Change Model



Note*:* Created by the author, adapted from Rogers (2003).

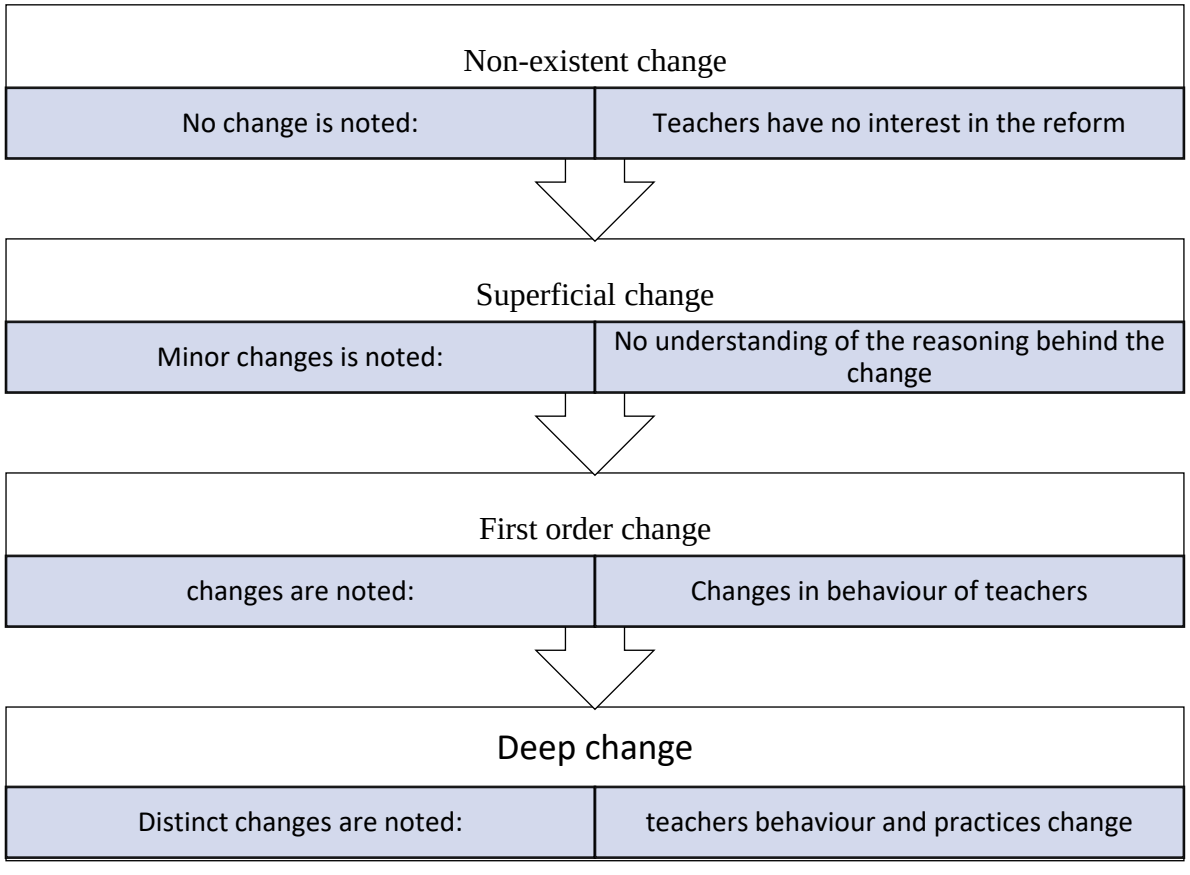
Teachers respond to change differently, yet proponents of policy reforms, such as the C&R curriculum, assume that introducing new educational objectives will result in consistent, significant, and long-lasting changes in teachers' attitudes and actions. Stated differently, it is necessary to

investigate the extent, significance, character, and durability of these changes among teachers rather than focus on the fact that C&R curriculum reforms merely bring about change. Such concerns motivated me to explore what the literature refers to as "Deep Change" to create a conceptual framework that would allow me to gauge and interpret the depth of change amongst teachers as they navigate the C&R curriculum reform. The study also draws on Fullan's (1993) Theory of Deep Change as a conceptual framework for exploring and explaining the (in)consistencies in the implementation of a C&R curriculum.

Deep change incorporates the notion of collaboration, which necessitates the development of professional communities and, in turn, the re-culturing of classrooms and schools (Fullan, 2005). The framework also argues for deep ownership of a curriculum as a means of achieving broader, more extensive pedagogical change, alongside other curriculum reforms (Fullan, 2004). Ownership entails not only a deep understanding and familiarity with a curriculum but also the teacher's favourable acceptance of it. Owning a curriculum implies that the teacher believes in the new curriculum and, by extension, in the reform. Deep learning is not only about working smarter and harder but also about accruing resources that enable one to go deeper and further (Fullan, 2005).

Figure 3.4(b)

The Different Types of Change



Note*:* Created by author, adapted from Fullan (1991)

There are different types of change: non-existent change, which is when there is no shift in the intended course (Fullan, 1991); superficial change, or minor changes of behaviour by teachers regarding the intended course or reform (Fullan, 1991), with no comprehension of the fundamental tenets and reasoning behind the change. First-order changes affect the practices and behaviours of teachers, whereas second-order, or deep change, addresses fundamental ideologies that alter the practices and behaviours of teachers implementing the reform (Kezar 2018). First-order and deep changes entail distinct change procedures; first-order changes are more continuous and recurrent, whereas deep changes are more linear and logical (Kezar 2018). Both categories of change can apply to the kinds of modifications that teachers at school frequently seek when implementing the C&R curriculum. For instance, when the Department mandates a change or reform, it considers a first-order change that unfolds in a clear, linear manner. The modifications the Department makes to better align the C&R curriculum with teachers' understanding of the C&R curriculum are examples of how curricular change can signal a deeper first-order change that goes hand in hand. Consequently, first-order change predominates in both change theory studies and most teachers' daily lives (sometimes to their frustration).

In a culture where accountability and efficiency are highly valued, the attention given to these initiatives is likely due to the ease with which first-order change is identified and evaluated. As stated by Kezar (2018), change that is so significant as to transform the operating environment, fundamental principles, and the behaviour of teachers and the school as a whole is referred to as a first-order change, or deep change. Teachers who follow change procedures without comprehending or embracing the deeper attitudes and ideologies that support a new reform may exhibit artificial change. If teacher habits do not change over time to reflect long-term changes that transcend the lifespan of the C&R curriculum reform, the transformation may be short-lived or unsustainable (Fullan, 2005), and there will be no deep change. Deep change occurs when teachers actively seek out the best information and concepts to support their learners in creating new meanings, solving problems, collaborating in various groups, and becoming independent thinkers in a continually changing environment (Fullan, 2005).

Deep change means accepting uncertainties while taking chances. When teachers embrace deep change, they stop viewing themselves as passive recipients of policy changes and start acting as active change agents (Fullan, 1993). It is necessary to investigate the extent, significance, character, and durability of changes among teachers rather than assume that policy changes, such as C&R curricula, bring about change. Deep change entails teachers leading by moral purpose; that is, undertaking modifications intended to improve learners' lives, despite their being incredibly challenging and complex (Fullan, 1991, 1993, 2004, 2005). Leading by moral purpose, although challenging, is a vital undertaking that requires interpersonal connections and reciprocal empathy across disparate groups (Fullan, 2005).

Deep change aims to combine the societal, religious, and philosophical elements of transformation (Fullan, 2004). Schools use an array of concepts about learning to create knowledge, which is the philosophical power. The societal element involves creating coalitions amongst various groups, both within and beyond the school, to mobilise power in support of educational objectives. The religious-moral element of deep change occurs through its impact on the daily lives of all learners. These three factors combine and reinforce one another to provide more energy, which

is necessary for autonomous innovations in multifaceted structures. According to this viewpoint, deep change essentially entails strengthening one's moral, emotive, and cognitive interactions and perceiving how these relationships reinforce one another. It entails implementing profound changes in education that involve the mind and the heart rather than merely conventional or professional behaviours.

3.4.1 Challenges in Implementing Deep Change

Leaders in educational development and policy reform, such as C&R curricula, must take into account the diverse range of challenges that teachers, as agents of change, may encounter if they hope to spearhead significant transformation or enable others to do so. Change agents will require assistance in navigating different levels of organisational culture to lead change. Furthermore, some teachers might not view themselves as change agents because there is no motivation to lead change, as the reform is usually not rewarded by promotion or tenure systems.

Teachers may lack content and pedagogical knowledge for the successful implementation of C&R, and thus implement the C&R curriculum with a superficial understanding, relying on methods from other subjects that are known or familiar (García-Carrillo et al., 2021). This is because the extant knowledge they bring to the new reform may prevent them from abandoning their old ways. Darling-Hammond et al. (2020) support this assertion, observing: "Deep change, in other words, necessitates the reconstruction of current individual and societal practice mindscapes." The researcher claims that teachers will implement C&R because they have to, not because they believe technology is essential for future citizenship. This is once again related to the extant knowledge they bring to the new reform, which will prevent them from abandoning their old ways and learning and using new ones.

The lack of content and pedagogical knowledge is also supported by Govender (2018), who argues that teachers were not provided with sufficient continuous professional development programmes and that there were limited opportunities for classroom support, coaching, and evaluation to guide their implementation of the necessary changes. To effect deep change, it is essential to develop teachers through professional development activities, which are instrumental in making a difference in the lives of individual learners by contributing to their personal development and impacting all learners for the larger social good (Fullan, 1991). Teachers must examine their own and shared visions, as well as the practice of new abilities over time. One cannot force a teacher to change, think differently, or acquire new talents. Teachers cannot make a difference in the classroom unless they also make a difference in the working environments that surround the classroom.

Indeed, going deeper and further requires time and energy, which often cannot be sustained over a long period. Contemporary reforms in information technology call for deep changes in both teaching and learning (MacDonald et al., 2020). The magnitude of the changes envisioned by these reforms suggests a need for both a deep understanding of the C&R curriculum and the implementation process. In South Africa, for example, where the teaching of information technology has been limited to a few due to resource constraints (Mkhize & Davids, 2021), the introduction of C&R for all learners in the C&R curriculum will require fundamental changes. The assumption in a deep change framework is that if deep change is recognised as a necessity for reform, its attainment will follow. However, because deep change takes a long time, teachers may find that the energy and time required to make the change is not feasible for them, due to personal obligations. This is a very real concern,

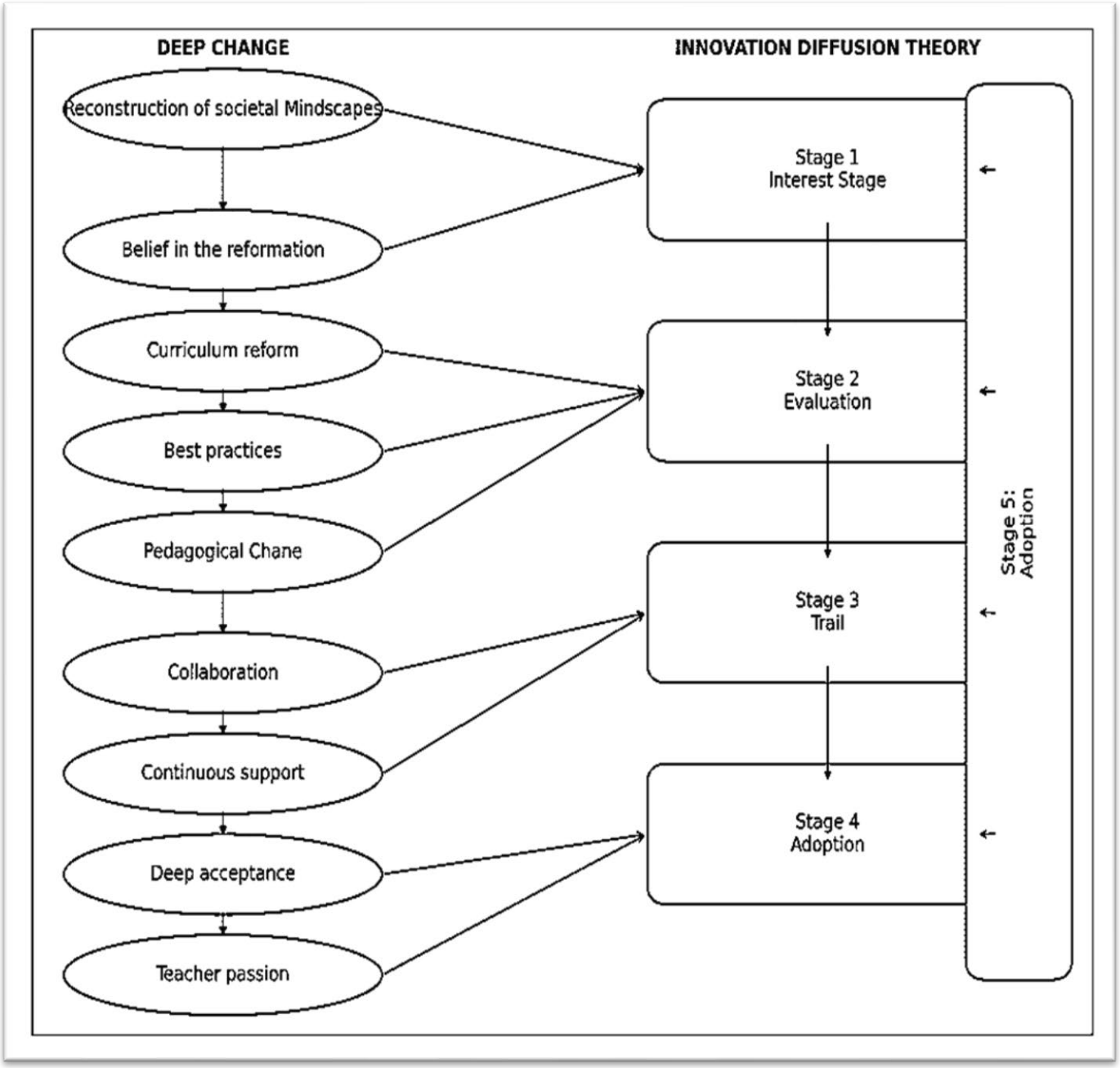
particularly in developing countries, where teachers face 'burnout' due to continuous change in adverse teaching environments (Hurley, 2021). As argued by Kezar (2018), Deep change cannot be mandated or forced, and that is one of its main obstacles. It calls for more than just making adjustments to easily monitored or evaluated processes. Rather, deep change entails continuously helping others understand the nature of the shift and highlighting its significance for learning (Kezar, 2018). To achieve deep change, teachers must be exposed to new ideas and given time and space to incorporate them into their existing beliefs. This can be done through an ongoing learning process that uses techniques such as sense-making and organisational learning. Only then can new approaches to curriculum or pedagogy be developed and deeply understood by teachers.

3.5 Conceptual Framework for the Study

Adoption through Deep Change and Diffusion Model (ADCM): An Integration of IDT and the Theory of Deep Change

Figure 3.5(a) - An Illustration of the Conceptual Framework for the Study

Adoption through Deep Change and Diffusion Model (ADCM)



Note*:* Created by the author

The ADCM conceptual framework integrates the structured stages of innovation diffusion with the principles of deep change to examine teachers' adoption and adaptation of the C&R curriculum. The framework proposes that clear communication and dissemination of curriculum innovation (DOI stages) influence teachers' knowledge and perceptions, teachers' deep understanding, ownership, and collaborative engagement (Deep Change principles) facilitate meaningful adoption, and the adaptation stage represents the new contribution of this study, highlighting how teachers tailor curriculum implementation to the needs of individual schools. By participating collaboratively across all diffusion stages, teachers

develop the capacity to adapt the C&R curriculum, ensuring its effective and context-specific implementation. This integrated framework enables the researcher to analyse the dynamic interactions among diffusion strategies, deep learning, and teacher adaptation to enhance curriculum delivery. This framework is premised on the notion that the adaptation and optimisation of curriculum outcomes are facilitated by integrating appropriate diffusion of the four stages of innovation and deep learning, thereby enabling the adaptation stage. The adaptation stage is the new stage created during the merging of the two theories to form the conceptual framework. The fifth stage is the adaptation of teachers according to the individual needs of their schools when implementing the C&R curriculum in the classroom. According to Niemi (2021), mutual vision, communication, dedication, and sufficient time for preplanning are needed for teachers to adapt the C&R curriculum to meet the individual needs of the school. There must also be deep change and proper diffusion of the innovation under scrutiny.

This framework suggests that if there is clear communication across the various stages of diffusion, then the perceived characteristics of the proposed innovation can lead to teachers' deep change in implementing and adapting the C&R curriculum. Thus, the integration of the constructs of the diffusion process and the proponents of deep change is critical to mobilise support for the innovation, by making information available about the innovation so that the teachers, as implementers of the innovation, understand what the best practices are and how to go about adapting them to meet the individual needs of the school. The study will examine how teachers experience the process of curriculum diffusion for C&R. By using the Theory of DOI and deep change reviewed above, this study posits that the extent to which teachers take an interest in, evaluate, engage in trial runs, adopt and adapt C&R is dependent on the societal mindscapes, belief in the reform, best practice, collaboration, deep acceptance, and the support received from the innovation diffusion process and therefore on their ability to adapt.

The framework proposes that teachers must participate collaboratively and continuously at all stages of the innovation's diffusion (Rogers, 2003), from the interest stage through to the adaptation stage. Therefore, this conceptual perspective is believed to offer a different strategy for analysing and understanding the tenuous relationship between strategies for managing curriculum diffusion and teachers' experiences in implementing innovation [such as C&R curriculum]. This framework will propose strategies to adapt the C&R curriculum diffusion process to achieve deep change, using the best practices identified by teachers in the study to improve the implementation of the C&R curriculum and to meet schools' individual needs. By participating collaboratively across all diffusion stages, teachers develop the capacity to adapt the C&R curriculum, ensuring its effective and context-specific implementation. This integrated framework enables the researcher to analyse the dynamic interactions among diffusion strategies, deep learning, and teacher adaptation to enhance curriculum delivery.

3.6 Conclusion

This chapter has described the conceptual framework for the study, which combines Rogers' (2003) IDT with Fullan's (1993) Theory of Deep Change to create the Adoption through Deep Change and Diffusion Model (ADCM). By critically engaging with both theories, the chapter has demonstrated that, while the diffusion process explains how innovations like the C&R curriculum spread, long-term and meaningful implementation necessitates the deeper engagement and ownership emphasised in the Theory of Deep Change. Including the adaptation stage as a fifth stage broadens previous theories by acknowledging teachers' roles in adapting innovations to their individual school needs. This conceptual

framework thus provides both the analytical lens and the theoretical underpinning for investigating how teachers in primary schools' encounter, understand, and adapt to the diffusion of C&R. It also highlights the critical interplay between dissemination processes, deep learning, and context-responsive adaptation in educational reform. The addition of the adaptation stage as a fifth stage extends existing Theory by recognising the need for teachers to adapt innovations to their specific school contexts. This conceptual framework, therefore, provides both the analytical lens and the theoretical foundation for examining how teachers in primary schools' experience, interpret, and adapt to the diffusion of C&R. It further highlights the critical interplay between dissemination processes, deep learning, and context-responsive adaptation in educational reform.

CHAPTER FOUR: Navigating the Research Terrain- An Interpretive, Qualitative Case Study Approach to Understanding Teachers' Experiences.

4.1 Introduction

The purpose of the previous chapter was to encapsulate the in-depth theoretical framework that guided this study. This chapter describes the research design and methodology intended to achieve the study's objectives. This chapter also includes a summary of the procedures used for participant selection, data-gathering methods, and data analysis strategies. In addition, the researcher discusses the responsibilities and potential ethical issues arising from data generation and analysis.

4.2 Research Paradigm

When conducting research, the researcher must situate their work within a specific research paradigm. It is within a particular paradigm that the researcher positions and aligns the research process by anticipating certain philosophical presumptions about how the C&R curriculum is disseminated to teachers and how knowledge, in the form of how teachers interact with the phenomena under study, is generated in the study (Bryman & Bell, 2019). This study employs the interpretive research paradigm to strengthen the philosophical assumptions about how the C&R curriculum is disseminated and how teachers who implement or are yet to implement it gather feedback.

As Cohen et al. (2018) note, the interpretive paradigm aims to understand and interpret human experience. Teachers engaging in the C&R phenomena are socially interactive; each teacher who participates will have a different view, understanding, and interpretation of the C&R curriculum. These views, understandings, and interpretations represent different realities that used to improve the teaching and implementation of the C&R curriculum. Therefore, the interpretive paradigm was appropriate for the study, as multiple worldviews and realities exist among teachers as they engage with C&R activities, whether in groups or individually (Nieuwenhuis, 2016). To truly understand the fundamental concept of the interpretative paradigm, the researcher began by taking on a specific viewpoint regarding knowledge (epistemology) and the foundations of reality (ontology), subsequently leading to the selection of particular methodology and beliefs (axiology) that informed the study (Kivunja & Kuyini, 2017; Merriam & Tisdell, 2016). Lincoln and Guba (1985) identify epistemology, ontology, methodology, and axiology as four components of a study's paradigm. According to Kivunja and Kuyini (2017), comprehending epistemology involves exploring the essential issue of how we know what we know.

Epistemology, as integrated within this study, refers to the understanding and recognition that the researcher gains about the C&R curriculum from participants who implement it. The researcher's involvement with the participants in constructing an interpretation and understanding of the C&R curriculum involves a subjective epistemology (Cohen et al., 2018). Subjective epistemology emphasises how the participant’s experiences

shape and justify their ideas about implementing the C&R curriculum. It asserts that the participants' individual experiences, interpretations, and settings are intrinsically linked to their knowledge and comprehension of the C&R curriculum (Cohen et al., 2018). Subjective epistemology examines how participants' views and knowledge are shaped by factors such as feelings, subconscious prejudices, personal experiences and interactions with others.

Epistemological assumptions focus on the knowledge-gathering process and the development of new knowledge (Kivunja & Kuyini, 2017). The researcher's interaction with participants during data generation focused on understanding their dynamics and experiences, including the challenges of implementing the C&R curriculum among primary school teachers, as reflected through their lens. Epistemological assumptions were used to understand how participants have arrived at their perceptions and experiences while engaging in the C&R phenomena in a social context.

Ontology is defined as a philosophical discipline that focuses on the inferences teachers make to conclude that their experiences implementing the C&R curriculum yield logical or true conclusions (Kivunja & Kuyini, 2017). Within the Interpretive paradigm, it is ontologically argued that there is no single reality, as reality is created socially by participants within a group. Ontology, as further examined by Kivunja and Kuyini (2017), is the exploration of the nature of existence, reality, and being or becoming, as well as the fundamental classes of things that occur and their relationships. It prompts the researcher to ask the questions about reality: Is it real? Or has it been constructed in one's mind? It was relevant to the study to probe the multiple realities participants construct in their minds as they implement the C&R curriculum. Ontology was therefore used to examine and understand the teachers' underlying belief systems as they implemented the C&R curriculum in their schools.

Methodology, according to Keeves (1997), is a general term that encompasses study design, methods, and procedures carefully planned to produce data. Methodologically, interpretive researchers use methods of data generation that allow for in-depth inquiry with participants. For the purpose of this study, the researcher interacted with and listened to participants through six different techniques: questionnaires, one-on-one interviews, collage creation, workshops, focus group interviews, and reflective questionnaires. These data-generation methods assisted the researcher in understanding the participants' experiences and their unique contributions to improving and implementing the C&R curriculum, as discussed in more detail below under section 4.7. Methodology also considers the assumptions made about the C&R curriculum, the constraints teachers face when implementing it, and the ways these constraints are overcome. Finally, axiology refers to the ethical considerations that must be taken into account when conducting research (Finnis, 1980). Axiology, according to Kivunja and Kuyini (2017), is the definition, assessment, and comprehension of ethical behaviour in relation to the research process which is discussed further below in this chapter.

4.3 Research Design – Qualitative Research Approach

The method implemented in this study for discovering and comprehending the interpretations teachers assign to the C&R curriculum is a qualitative research design approach (Creswell & Creswell, 2018). Qualitative design employs a variety of data-generating tools or methodologies, such as diary entries, discussions, interviews (including semi-structured), pictures, assessments of documents, audio recordings,

and journals (Creswell and Poth, 2018). The data-generating tools utilised for this study were questionnaires, one-on-one interviews, collage creation, workshops, focus group interviews, and reflective questionnaires. The researcher relied on data generated with these tools to gain a deeper understanding of teachers' experiences implementing the C&R curriculum, as qualitative studies are interpretive and seek to comprehend social reality through others' perspectives (Bryman & Bell, 2019). Qualitative research design, according to Creswell and Creswell (2018), maintains its roots in the social sciences, anthropology, and humanities, and relies heavily on understanding participants through data gathered from them and their interpretation. These researchers also list research using narratives, phenomenological-ethnographic methodology, and case studies as examples of qualitative research designs. Motivated by the above contentions, this study aligns well with a qualitative design, as it seeks to understand teachers' experiences implementing and teaching the C&R curriculum, to improve it.

Qualitative research is advantageous for both the researcher and the participants, as it allowed the researcher to experience the world through participants' perspectives (Bryman & Bell, 2019). Consequently, within the qualitative research design, the researcher was able to empathise with and understand participants' actual experiences of implementing the C&R curriculum, without passing judgement on participants' background understanding of technology or the infrastructural challenges that may arise at their individual schools. Furthermore, qualitative research emphasised the process of data creation, allowing participants to reflect on their experiences before or immediately after an event (Bryman & Bell, 2019). The event in this study was the C&R workshops. Participants' experiences were gathered during one-on-one interviews before conducting the C&R training workshops, followed by focus group interviews immediately after the workshops, and finally, reflective questionnaires once the participants return to their schools and implement what they have learnt. In this way, participants were able to look back and reflect on their experiences, understanding, and views of the C&R curriculum both before and after the workshops.

A key characteristic of qualitative research, as argued by Busetto et al. (2020), is that it studies the nature of phenomena, including their quality, different manifestations, and the contexts in which they appear or the perspectives from which they are perceived. Qualitative research, as implemented in this study, helped facilitate understanding of teachers' perceptions of their experiences and the strategies needed for the effective implementation and teaching of the C&R curriculum. It was relevant to this study, as the researcher explored teachers' experiences in their natural setting—the school where they teach C&R. Qualitative research methods, as stated above, entail interpreting multiple realities epistemologically to understand the phenomenon's main meaning (McMillan & Schumacher, 2014). The different experiences of teachers while implementing and teaching the C&R curriculum constitute the multiple realities they have created, which are present in the study. To interpret the various realities arising from teachers' experiences and perceptions in implementing C&R at school, the researcher adopted the interpretivist paradigm as explained above.

The researcher proceeded with caution, using a qualitative research approach while being aware of its shortcomings. In particular, qualitative research design is commonly criticised for being overly dependent on the researchers' views and beliefs, making them too arbitrary (Bryman & Bell, 2019). To address this challenge, the researcher was intentional in contrasting participants' views and beliefs with their experiences implementing the C&R curriculum, ensuring that their opinions and beliefs emerged from their experiences, not the researcher's beliefs. Furthermore, qualitative research methods have been challenged for appearing prejudiced because researchers select participants and use

sampling methods that include probing during interviews (Bryman & Bell, 2019). While this may be seen as a challenge, participants were purposefully selected to understand the phenomena under study, ensuring that relevant data were collected and interpreted to fulfil the aim of the study. The method of participant selection is further examined in Section 4.5 below. Mohajan (2018) states that qualitative research approaches are typically tedious, requiring significant effort for data acquisition, processing, and evaluation. As a result of this complexity, crucial concerns may be frequently missed and go unreported; hence, member checking, audit trails, and the supervisor's involvement in often examining the data generation and analysis process was part of the overall procedure of making sure that the outcomes remained credible (Lincoln & Guba, 1985).

4.4 Positioning the Study Within the Case Study Design

Methodology refers to the strategies that the researcher used for sampling, data gathering, documentation, and data analysis to understand the phenomenon under scrutiny (Maree, 2012). A qualitative design includes various research methodologies such as narrative research, phenomenology, grounded theory, ethnography, and case study (Bryman & Bell, 2019; Creswell & Creswell, 2018). This study employed a qualitative research design within an interpretive paradigm (as established above) and used a case study design. The case study research design was adapted into this study because it is an exploration of a case through detailed, in-depth, and intensive data-gathering methods such as one-on-one interviews, collage creation, workshops, focus group interviews, and reflective questionnaires conducted after the workshops; hence, those was the different sources used to gather information in this study (Mishra & Dey, 2021).

Yin (2018), a key scholar in case studies, identified three types: exploratory, explanatory, and descriptive. He defines an exploratory case study as one that investigates a previously unknown occurrence, which can serve as the foundation for future research. An explanatory case study, as explained by Yin (2018), seeks to explain what or why something occurs in a specific case. Finally, a descriptive case study provides a comprehensive explanation of an occurrence in its setting (Rule & John, 2011; Yin, 2018). This study adopted a descriptive case study design because its focused on teachers' experiences as they implemented the C&R curriculum before and after the researcher's training workshops. Further, a case study consists of a specific case, with the focus either on an intrinsic case or an instrumental case (Stake, 2015). Consequently, a contrast was drawn between intrinsic and instrumental case studies. The intrinsic case study focuses on the case as a distinctive or novel circumstance warranting further investigation (Rule & John, 2011). In contrast, an instrumental case study focuses on a specific theme (Busetto et al., 2020). This study adopted an intrinsic case study which focused on teachers' experiences, challenges, and perceptions of the new subject, C&R. The focus of this study was the experiences of ten teachers implementing the C&R curriculum and ways to improve it based on those experiences.

The inherent benefits of a case study justified its adaptation in this study and are mentioned as follows. Rashid et al. (2019) assert that a case study identifies the relationship between the phenomenon and the social context in which it exists. Within this study, a relationship existed between teachers' experiences implementing a C&R curriculum and the social context of the school setting. The social context played a crucial role in the proper implementation of the C&R curriculum, since a well-resourced school may yield different outcomes than one that is not.

Another benefit of a case study design, as explained by Rashid et al. (2019), is that it allowed for flexibility in data generation, as utilised in this study and described above.

Despite its benefits, as mentioned above, one must also acknowledge the limitations of the case study design. Case studies are rarely similar, so the information they yield is often incomparable. This is because the participants in the case study relate the narrative according to their own belief system; hence, the researcher was aware of this and read rational notions and units of scientific classification into or out of it. Case studies are also time-consuming and can incur significant costs (Yin, 2014). Another limitation was that a case study design is employed only within a limited scope and thus cannot be applied to a large society. As such, this study was not contending to generalise its findings but to understand and interpret the experiences of the teachers in implementing C&R, with the intention of making recommendations to improve the C&R curriculum. The conclusions from the data generation methods was anticipated to be sufficient to make recommendations.

4.5 Sampling and Sampling Process

Sampling techniques are used in case studies to minimise resource costs and ensure that the data gathered are representative of the larger population. Sampling saves time and effort by enabling researchers to infer about a population without polling every member of the population (Patton, 2020). It is especially useful in situations where gathering data from every person would be problematic due to logistical constraints or when the population is huge (Creswell & Creswell, 2020). According to Kelly (2010), sampling is the most important component of any research project, as it establishes the foundation for participants' opinions on the phenomenon, regardless of their perspective. According to Cohen et al. (2018), sampling involves selecting individuals or sources to generate data. Furthermore, researchers employ a variety of sampling techniques to identify cases, research sites, and participants, and to choose and recruit them for the study. Examples of qualitative sampling strategies or procedures include convenience sampling, quota sampling, purposive sampling, snowball sampling, volunteer sampling, and theoretical sampling (Cohen et al., 2018). The abovementioned sampling strategies are characterised as non-probability sampling, which is only applicable in qualitative research because the researcher only selects certain examples and participants to examine the phenomena, or when the whole population is unknown (McMillan & Schumacher, 2014). This approach differs from probability sampling, which is exclusively used in quantitative studies and requires the researcher to recruit subjects or responders who resemble the larger community (McMillan & Schumacher, 2014). Qualitative studies have smaller sample sizes than quantitative studies, as they aim to gather information to better understand the phenomenon. In contrast, quantitative studies attract individuals who represent the larger population, enabling generalisation of the results to the population as a whole (McMillan & Schumacher, 2014).

For this study, the researcher used purposive sampling. Purposive sampling is the process of selecting individuals deemed well-informed about a phenomenon; thus, it is primarily used in qualitative research (Cohen et al., 2018). Busetto et al. (2020) concur with the above definition in stating that purposive sampling is the selection of particular participants who have specific knowledge about a certain interest; hence, the participants selected were either implementing the C&R curriculum at their school or were in the process of implementing the C&R curriculum

at their school. Furthermore, Cohen et al. (2018) state that purposive sampling depends on the expected richness and usefulness of the data in relation to the research objectives. Purposive sampling notes that the population of interest might include intrinsic variability (Wolcott, 2008).

While purposive sampling can yield excellent results, it is not guaranteed to succeed (Cohen et al., 2018). Furthermore, as determined by Cohen et al. (2018), the success of purposive sampling depends on the assumption that the researcher identifies beforehand the traits that encompass all variances and that the chosen sample accurately represents the distribution of these features. The researcher strived to address the above by selecting a sample representative of the entire population; hence, one teacher was chosen from each school, and 10 teachers representing their individual schools were selected. All selected teachers were from the Foundation Phase (Grades 1-3) because the C&R roll-out began there; hence, these teachers were better positioned to provide rich information for the study. All participants were from public schools within the Pinetown District and were selected according to the socioeconomic quintile classification of their schools. However, Quintile 1 schools were not included in the study. This decision was informed by both practical and contextual considerations. Quintile 1 schools are predominantly located in rural or remote areas (Department of Basic Education [DBE], 2020; Spaull, 2019), and because the study was geographically confined to the Pinetown District-an urban and peri-urban district-it was not feasible to source Quintile 1 schools for participation. Rural schools often face unique geographical and infrastructural barriers, including limited transport access, dispersed populations, and fewer technological resources (Nkosi, 2021; Spaull, 2019), making their inclusion impractical within the scope of this district-based study. Consequently, the sample was drawn from Quintile 2-5 schools, which were accessible within the district and aligned with the study's logistical and contextual constraints. Although purposive sampling can enhance internal validity, it may limit the generalisability of findings due to selection-related biases (Nikolopoulou, 2022). Acknowledging this, the researcher remained mindful of potential bias and took conscious steps to consider the diversity of teachers' experiences when selecting participants and interpreting the findings.

4.6 Data Generation Methods

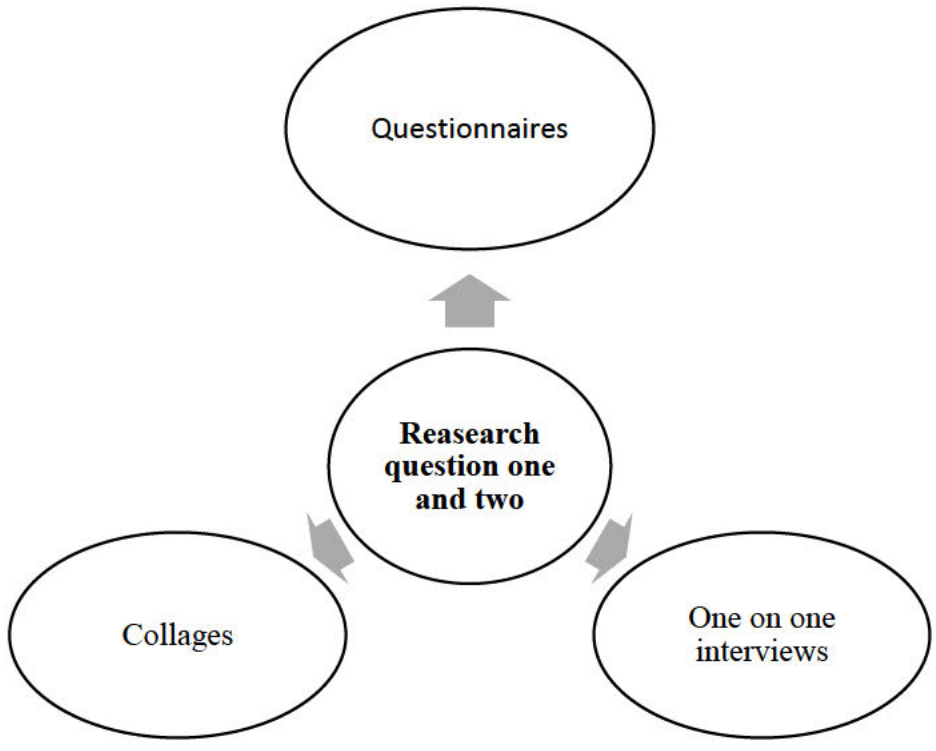
According to Creswell and Guetterman (2018), data generation methods are the key to a successful research project, as they determine the quality of data generation during the research process. The researcher utilised various methods to collect data, as detailed below, which elicited self-reflection and critical thinking among the participants. The justification for using the various methods for data generation is crystallisation. As de Vries and Reinmann (2018) state, crystallisation is the process of confirming outcomes through the use of numerous data-generation and analysis techniques. A qualitative researcher quilts together a wide range of data by combining interviews, observations, archival materials, photographs, and texts (Stewart & Gapp, 2017). This study supports crystallisation, as it provided a clearer prism through which the researcher viewed the elements that constitute qualitative research using various data generation methods, thereby increasing the study's credibility (Maree, 2016).

Crystallisation also served as a foundation for qualitative research since this study is situated within the interpretive paradigm, which created a subjective epistemological posture to generate knowledge and relative ontology in which significance was generated by means of the collaboration between the researcher and the participants during the workshops, interviews, reflective questionnaires and collage-making sessions

(de Vries & Reinmann, 2018). Consequently, since crystallisation emphasised the creation of knowledge through intensive conversations between the researcher and the teachers during data generation, it adopted a social constructionist epistemological perspective (de Vries & Reinmann, 2018). The different methods of data generation were examined in depth and discussed below. The integration of the various data generation tools for addressing the three research questions were further explored in phases one to six, discussed in section 4.8, and displayed in diagram form. The data generation tools utilised in the study were all developed by the researcher. The first three data generation tools were designed to answer Research Questions one and two. The next three data generation tools were designed to answer Research Question three. The visual representation below reflects the research questions and the corresponding data generation tool employed to answer that particular research question.

Figure 4.6(a)

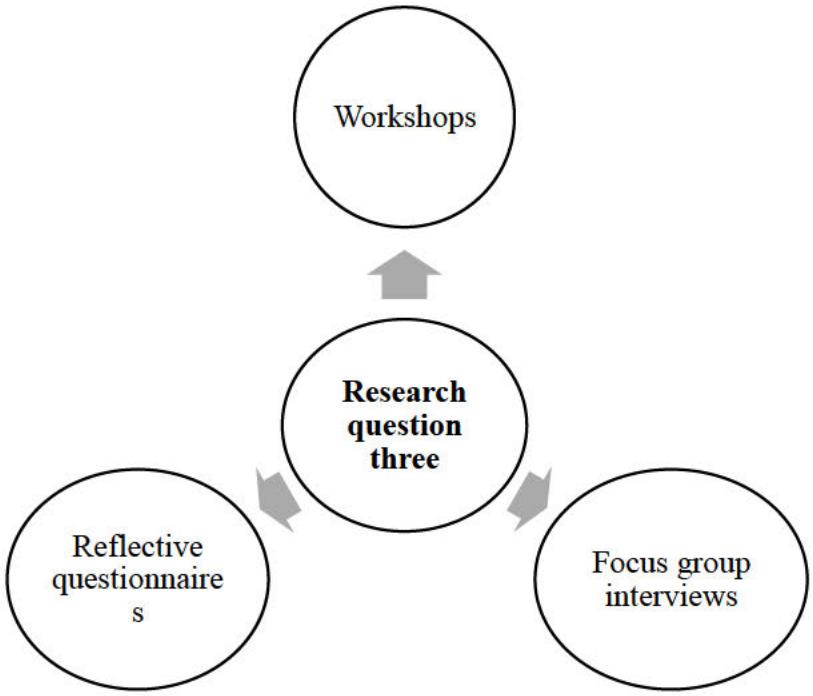
Phase One



Note: Visual representation created by the author

Figure 4.6 (b)

Phase two



Note: Visual representation created by the author

4.6.1 Questionnaires

This study utilised questionnaires (see Appendix A) as a data generation tool to understand participants' experiences implementing the C&R curriculum, their demographic information, and their socioeconomic status, thereby providing an organised and comprehensive understanding (Creswell & Poth, 2018). The collection of demographic information in this study was fundamental because it allowed for clarity on the diversity of participants, which affected their teaching methods and pedagogical viewpoints. According to Xie (2020), there are correlations between resource availability and socioeconomic backgrounds, which was represented by school quintiles. This was especially true for technology-based curricula such as the C&R. This demographic data, collected via questionnaires, including age, gender, and school quintile, enabled the researcher to examine relationships among these variables and participants' experiences in implementing and teaching the C&R curriculum. For example, due to differing degrees of technological familiarity, older teachers may approach C&R differently than their younger counterparts (Horsley, 2017). Similarly, participants' capacity to successfully teach C&R curriculum was directly impacted by their access to technology, including computer laboratories and reliable internet connectivity (Bennett et al., 2020). Therefore, questionnaires made it easier to explore correlations by allowing the researcher to examine how participants' teaching experiences were influenced by their demographic and socioeconomic information.

4.6.2 Semi-Structured Interviews

Cohen et al. (2018) define an interview as two or more people sharing their opinions on a subject that is of interest to them both. He further eludes that researchers perceive interviews as a versatile data generation approach that allows the utilisation of multisensory channels, including spoken, nonverbal, visual, and auditory information. According to scholars like Cohen et al. (2018) and Creswell & Creswell (2018), there are various types of interviews which are frequently utilised to gather data in research; they are as follows: standardised interviews, in-depth interviews, structured interviews, unstructured interviews, semi-structured interviews, face-to-face interviews, telephone interviews, informal conversation interviews, and focus group interviews.

This study utilised semi-structured one-on-one interviews as the primary data generation method. To obtain rich data, interviews were conducted in two phases: a pre-workshop interview and a post-workshop focus group interview. According to Ruslin et al. (2022), semi-structured interviews are a cost-effective tool for gathering in-depth data on teachers' experiences with the implementation of the C&R curriculum. Semi-structured interviews allowed the interviewer to control the direction of the interview process to obtain detailed and relevant data Cohen et al., 2018). Semi-structured interviews allowed the researcher to gather information from teachers implementing or soon to implement the C&R curriculum, to improve the C&R curriculum based on their real-life experiences.

Semi-structured interviews helped the researcher gain insights from teachers on how effective the training in the C&R workshops is and how best to improve it, if needed. It also provided relevant insights from participants on the effectiveness of the C&R curriculum. Each semi-structured interview lasted roughly an hour. As explained by Gundumogula (2020), one-on-one interviews are a more in-depth method in which participants engage in a regulated, planned debate about a specific topic. In that regard, the researcher developed a semi-structured interview schedule with all the questions to be asked participants regarding their experiences implementing C&R. To guarantee that the interviews were successful and yield the information rich data to meet the study's objectives, the researcher adhered to the rules set forth by De Vos et al. (2011) when conducting interviews with the participants': the questions were concise and unambiguous, each question was posed separately, the questions were semi-structured (see Appendix B), hence participants were free to respond however they saw fit and despite permitting freedom of expression, the researcher ensured that the focus was on the questions being asked with minimal deference from the question.

4.6.3 Collages as Visual Data

A collage is an arts-based approach gaining stature as a research methodology across many disciplines, including education (Gill et al., 2021; Woods & Roberts, 2016). Collage-making involves selecting and cutting images from magazines, newspapers, and other print media to paste onto a poster in a particular arrangement that represents the participant's narrative of a particular issue (Thill & Wiggins, 2020). As Thill and Wiggins (2020) explain, these images represent participants' feelings and experiences. The collage served as a means to conceptualise ideas; it offered a different way to portray the nuances of experience, profound feelings, and understandings of teachers as they experienced the C&R curriculum (Woods & Roberts, 2016). Therefore, collage creation allowed participants to engage physically in the process (Culshaw, 2019),

which the researcher viewed as an advantage for exploring their experiences. Hence, creating the collage enabled participants to explore their experience in different ways. Participants were grouped into teams of three, in which they developed the collages at their own pace and could reflect, move pieces, and rearrange as their thinking evolved.

The decision to use the collage was motivated by the fact that the researcher worked with teachers who were accustomed to using visual texts as teaching aids, as they teach in the Foundation Phase, where teachers constantly interact with them. However, the researcher was prepared for one or more participants to refuse to engage with the collage. In that case, at the beginning of the workshop, the researcher ensured that the process and intention behind developing the collage was thoroughly explained to alleviate any fears that may arise among participants. Ultimately, the decision to use collages was motivated primarily by the freedom of expression it offered participants. It relieved them of the burden of sketching and allowed them to express themselves without depending on perceived aesthetic talent (Woods & Roberts, 2016).

4.6.4 Workshops

Workshops provided a critical methodological tool in this study, intended to enhance teachers' abilities while also collecting data on their experiences with the C&R curriculum. Workshops allowed participants to engage in cooperative, hands-on learning that mirrored classroom reality. According to Darling-Hammond et al. (2020), productive workshops empower teachers to practice novel teaching methods in realistic settings, promoting both individual and systemic progress. In this study, workshops focused on unplugged activities linked to the CAPS C&R curriculum for the Foundation Phase, allowing participants to explore computational thinking and algorithmic design using everyday resources. This strategy not only reduced reliance on high-cost digital tools but also highlighted context-sensitive pedagogies appropriate for under-resourced schools.

Furthermore, workshops served as an intervention to investigate how teachers perceive and adapt the C&R curriculum when provided with structured opportunities for practice and reflection. Research on professional development for teachers highlights the need for repeated cycles of practice, evaluation, and analysis to increase confidence and sustain change (Kennedy, 2021; Opfer & Pedder, 2020). The workshops in this study included the following cycle: teachers first engaged in problem-solving tasks, then participated in post-workshop focus group interviews, and finally completed reflective questionnaires to evaluate long-term classroom application. This layered design allowed the researcher to capture shifts in teachers’ attitudes, pedagogical strategies, and perceived challenges before and after the intervention.

According to Avalos (2021), professional development is most effective when training is practical and context-driven. The workshops in this study achieved this by engaging with the content within the lived reality of South African primary schools, encouraging peer learning and recognising teachers' voices as curriculum implementers. In doing so, they not only improved teacher readiness but also created valuable data that directly addressed the study's final research question: How can you adapt the C&R curriculum to meet the needs of your school? Thus,

workshops served as both an instructional intervention and a research tool, emphasising their importance in the study's methodological framework.

4.6.5 Focus Group Interviews

Focus group interviews was utilised in this study to elicit rich data from participants through in-depth conversations about the complexities of their experiences implementing the C&R curriculum. Krueger and Casey (2020) assert that focus groups enable researchers to examine participants' attitudes, representations, and perceptions of a particular issue by utilising the interaction dynamics of group conversations. The semi-structured focus groups facilitated the investigation of the participants' experiences implementing the C&R curriculum by allowing participants to voice their opinions and experiences freely (Hennink et al., 2019). Participants also had the freedom to build on each other's ideas. The researcher played an integral role in the focus group interviews by ensuring that all participants engaged in the discussions and that their voices was heard. This is especially important because of the risk of aggregation or louder voices in the group drowning out quieter ones, which could distort the results. To mitigate this challenge and improve the effectiveness of the focus group interviews, the researcher adopted strategies from recent studies by Hennink et al. (2019), such as using deliberate questions and cues to involve more reserved participants.

4.6.6 Reflective Questionnaire

A reflective questionnaire (see Appendix D) was used in this research as a useful tool to assess participants' grasp and understanding of implementing and teaching the C&R curriculum after the workshops were conducted. In addition to evaluating participants' comprehension of the C&R workshops, reflective questionnaires were used to determine whether the workshops were effective in guiding and training teachers to implement what they learnt in their classrooms. Reflective questionnaires, as asserted by Smith et al. (2018), promote critical thinking, improve educational opportunities, and serve as a tool to guide the improvement of future teaching approaches used to implement the C&R curriculum. Participants in the study were asked to express their feelings, ideas, and learning objectives through reflective questionnaires after the workshops. Hattie (2015) concurs with the above statement, stating that reflective questionnaires are an essential part of post-workshop evaluations, as they promote deeper comprehension and can greatly improve the learning process. Reflective questionnaires have been shown to improve participants' learning outcomes in numerous studies. According to a meta-analysis by Hattie (2015), performance improvement is strengthened by critique, particularly reflections after a workshop. Reflective questionnaires are frequently used in workshops to boost participant engagement and satisfaction, resulting in more powerful and successful learning opportunities.

Despite the notable advantages of utilising reflective questionnaires, there are also disadvantages. Firstly, participants may find it difficult to reflect on themselves, and their answers might be geared to impress the researcher rather than accurately reflect what they have learnt (Davis, 2017). In this instance, the researcher will convey to the participants the value of providing accurate, true reflections of their experiences. Second, analysing qualitative data can be tedious, making the evaluation process more difficult (Davis, 2017). The researcher mitigated this challenge by ensuring that data were captured and transcribed accurately and that the data analysis process was not rushed, thereby minimising errors.

4.7 Data-Generation Process

The data-generation process comprises six phases. Each phase is discussed further below.

4.7.1 Phase 1: Questionnaire

The initial phase of the data-generation process involved administering questionnaires to all participant's. The primary purpose of the questionnaire was to collect demographic data from participants. This included information such as age, gender, years of teaching experience, availability of technological resources (e.g., internet access and computer laboratories), and the quintile classification of their schools. Such demographic information was essential for providing insight into participants' diversity and understanding how these factors influenced their experiences with the C&R curriculum. The questionnaire data were particularly relevant in addressing Research Questions one and two of the study. Table 4.7.1(a) below summarises the demographic information collected.

Table 4.7.1(a)

Age, gender, and years of experience of the participants were extracted from the questionnaires

Participants' Name (Pseudonym)	Gender	Age of Participant	Participants' Quintile
Participant 1	Female	58	5
Participant 2	Male	35	4
Participant 3	Female	56	2
Participant 4	Female	46	5
Participant 5	Female	42	5
Participant 6	Female	52	2
Participant 7	Female	26	2
Participant 8	Male	29	4
Participant 9	Male	39	3
Participant 10	Male	48	3

Analysis of the data shows that participants from lower quintile schools were generally older than those from higher quintile schools. For example, participants in quintile 2 schools averaged 53 years of age, while those in quintile 4 averaged 32. Class sizes also varied by quintile: quintile 5 schools had the smallest average class size (39.3), while quintiles 3 and 2 schools had larger classes, averaging 47 and 46 learners, respectively.

In terms of gender, six participants were female and four were male. This distribution reflects broader trends in the South African teaching

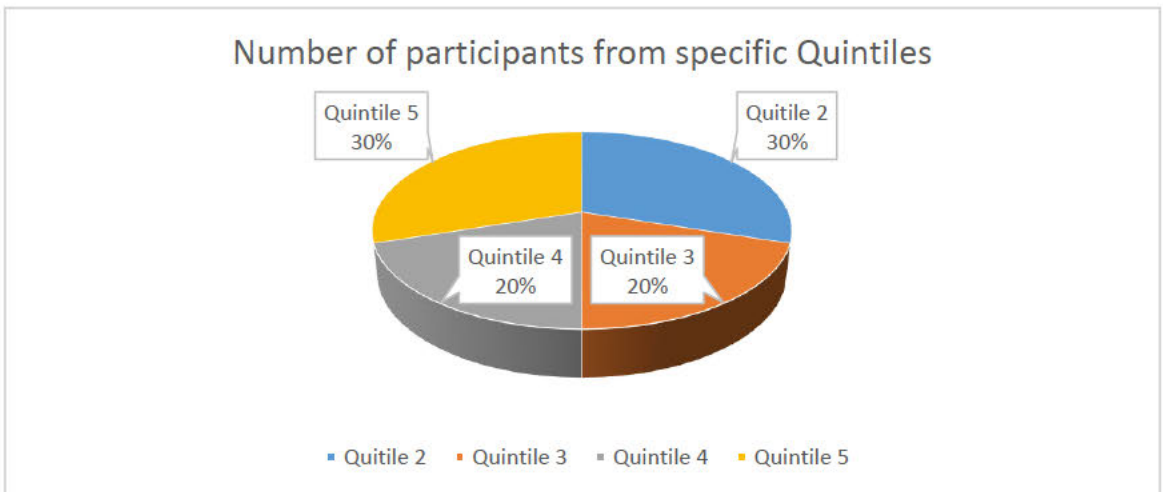
workforce, where approximately 70% of teachers in public schools are female (DBE, 2022). Recruiting equal numbers of male and female participants was therefore challenging. Gender dynamics in teaching also shaped perceptions of who is better suited to deliver C&R. Research suggests that male teachers are often assumed to be better prepared to teach technical subjects due to societal stereotypes (Diekman et al., 2020). In addition, Smith and Kearney (2021) found that learners often perceived male teachers as more relevant for teaching coding, which positively influenced their engagement and enthusiasm for programming activities.

The demographic data collected through questionnaires, therefore, provided an important foundation for examining participants' experiences with C&R. For instance, older teachers may approach the subject differently depending on their levels of technological familiarity (Horsley, 2017). Similarly, gendered teaching practices can significantly influence how the subject is taught (Berk, 2018). These demographic insights helped the researcher later connect themes that emerged in interviews and collage activities with participants' backgrounds, ultimately contributing to a deeper understanding of the C&R curriculum's implementation.

Although this study uses a qualitative research approach, certain demographic information about participants (such as age, gender, teaching experience, and qualifications) was collected and presented graphically. These demographic characteristics was summarised using tables and basic graphical representations (e.g., bar charts or pie charts) to provide a more complete picture of the participants. This descriptive presentation has no impact on the qualitative aspect of the study but rather helped to contextualise the participants and improved the comprehension of the qualitative findings.

Figure 4.7.1 (b)

Pie chart reflecting the different quintiles of the participant



Note. Author-generated graph.

As shown in the figure, three participants were from quintile 2 schools, two from quintile 3, two from quintile 4, and three from quintile 5. Previous research highlighted that socioeconomic status, closely linked to school quintile, played a significant role in shaping the implementation

of the C&R curriculum in South Africa (Van Dyk & White, 2019). For this reason, participants were purposively selected across different quintiles to ensure diverse representation of experiences and perspectives. This sampling approach enhanced the credibility and transferability of the findings (Van Dyk & White, 2019).

The connection between schools' quintiles and their social context in relation to the implementation of the C&R curriculum are further explained in the discussions that follow. The researcher included schools across different quintiles to gain a comprehensive picture of the implementation of the C&R curriculum and to identify significant patterns and trends influenced by school context. The researcher used a purposive sampling technique to select schools across various quintiles, aimed to gather a diverse range of experiences and opinions. This specific sample method enabled the researcher to highlight the differences and nuances that persist across various socioeconomic circumstances, thereby increasing the reliability and generalisability of the findings (Creswell, 2020; Patton, 2020).

4.7.2 Phase 2: One-on-one Interviews

The researcher conducted one-on-one semi-structured interviews with ten participants to determine teachers' experiences in implementing and teaching the C&R curriculum. The interviews were conducted before the workshops; hence, phase one was the pre-workshop phase. Participants were allowed to select the venue for the one-on-one interviews, and all chose to conduct them in their individual classrooms at the end of the school day. The participants expressed that their classrooms were the place where they felt most comfortable, which concurs with Creswell and Poth (2018), who assert that when interviews are conducted in an environment that participants feel safe and secure in, they are more likely to be open to answering the research questions without fear or intimidation (Creswell & Poth, 2018). The one-on-one interviews was used to answer Research Questions 1 and 2 in this study.

4.7.3 Phase 3: Collage-Making

In the third phase of data generation, teachers engaged in collage-making to explore their current experiences of implementing C&R before the workshops. The researcher began by explaining collage-making, using a pre-made sample. The researcher used prompts to elicit their views. In the collage exercises, the participant had to reflect on what they wanted to include in their collages and how those choices reflected their experiences. The researcher provided all the stationery and materials for the collages and allocated two hours for thinking and the actual creation of the collages. The participants from each group narrated their collages. Using a discussion schedule, the researcher engaged participants in interpretive group discussions (IGDs) to supplement data generated through collage. IGD is a participatory tool used to interpret and re-analyse existing data with participants (Redman-MacLaren et al, 2014). The researcher used the collages and preliminary discussions as tools to guide deeper reflection on their experiences implementing C&R. The researcher identified emerging themes from the participants' collages and the transcription of their recorded narratives; hence, the researcher was able to make meaning and connections from the experiences of implementing the C&R curriculum. The collages were used to answer Research Questions one and two of the study.

4.7.4 Phase 4: Workshops

The workshops, conducted was an integral component of Phase 4, designed to empower participants with practical skills by leveraging limited resources to emulate C&R Unplugged activities within a real-world context. The efficacy of the workshops in addressing research Question three was dependant on experiential learning, thereby informing the refinement of implementation strategies. The workshops were used to answer Research Question three of this study. Below is a table that clarifies the workshop topics, activities, and duration.

Table 4.7.4(a)

Mapping the Workshops with the Title, Activities, and Duration

Workshop	**Topic**	**Activities**	**Duration**
1.	Introduction to C&R Unplugged. Problem-based learning *Adapted from CAPS C&R for the Foundation Phase Grades R-3. p. 15*	Apply computational thinking skills to develop a set of logical instructions to solve a problem. Find the shortest route for the Uber delivery person. Appendix 6	4-5 hours
2.	Algorithms and Coding Adapted from CAPS C&R for the Foundation Phase Grades R-3. p. 28	Part A – Leveraging limited resources to design a robot. Appendix 7	4-5 hours
3.	Algorithms and Coding *Adapted from CAPS C&R for the Foundation Phase Grades r-3. p. 28*	Part B – Leveraging limited resources to design a robot. Appendix 8	4-5 hours
4.	Problem-Solving *Adapted from CAPS C&R for the Foundation Phase Grades R-3. p. 29*	Mimic the operations of a robot. Caryn, the crane driver. Appendix 9	4-5 hours
5.	*Adapted from CAPS C&R for the Foundation Phase Grades R-3. p.27*	Recognise and interpret patterns in a symbolic sets of data visualisations. The short and tall of it. Outdoor activity. Appendix 10	4-5 hours

4.7.5 Phase 5: Focus Group Interviews

Phase 5 involved conducting focus group interviews subsequent to each workshop to solicit participant feedback. These interviews investigated the efficacy of existing implementation strategies, the support systems available to educators, and schools' capacity to successfully integrate the C&R curriculum. By analysing participants' perspectives post-workshop, the researcher sought to ascertain whether their viewpoints had undergone a paradigmatic shift, thereby addressing the third research question. The questions were semi-structured and aimed at exploring the effectiveness of the implementation strategies used to manage the diffusion of the C&R curriculum. The focus group interviews lasted 45-60 minutes.

4.7.6 Phase 6 – Reflective Questionnaires

The final phase of the study, Phase 6, involved administering reflective questionnaires three months after the workshops concluded. This phase was designed to evaluate the workshops' efficacy and to ascertain whether participants were able to effectively utilise the tools and skills acquired during the workshops to adapt the C&R curriculum to the specific needs of their respective schools. By obtaining feedback from the participants after they had applied the skills gained from the workshops, the researcher aimed to assess the long-term impact of the workshops, thus providing valuable insights into Research Question three. The feedback from reflective questionnaires was used to answer Research Question three of this study. Below is a table listing each phase of data generation used in this study and the research question it addressed.

Table 4.7.6(a)

Mapping the Research Questions against the Data Generation Tool

Research Question	**Data collected informed by**
RQ1: What are teachers' current experiences of the implementation and diffusion of the C&R curriculum in primary schools?	Phase 1/2/3
RQ2: Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum?	Phase 1/2/3
RQ3: How can the C&R curriculum be adapted to effectively address the specific needs and contextual realities of the school?	Phase 4/5/6

4.8 Analysing the Data

The data collected through questionnaires, one-on-one interviews, collages, workshops, focus group interviews, and reflective questionnaires was analysed. This entailed classifying, characterising, accounting for, and elucidating data according to participants' interpretations and comprehension of how to improve the experiences and teaching of the C&R curriculum by identifying all patterns, themes, and categories from the constructed data (Cohen et al., 2018). To make data analysis easier, the data were systematically captured. Written notes, collages, and audio recordings of the interviews was captured and transcribed using TurboScribe and Otter.ai.

The two main steps of qualitative data analysis, according to Ritchie and Lewis (2003), are data management and interpretation of the data using either descriptive or explanatory accounts. Data management is important because large amounts of data are produced in qualitative studies (Ritchie and Lewis, 2003). As Terry et al. (2017) assert, the researcher may gain insight into participants' shared values and viewpoints through thematic analysis. Cruzes et al. (2015) define thematic analysis as a method for locating, examining, and summarising patterns and meanings (themes) from the participant data. Once the data were gathered, thematic analysis ensued, in which the researcher carefully examined the data to identify common themes and the subthemes that emerged from them. Using a theme framework was one way to manage and describe qualitative data (Dawadi, 2020).

Cohen et al. (2018) assert that there are five techniques for classifying and organising qualitative data during thematic analysis: by instrument, by issue, by group, by individual, and by research question. To manage and display the data analysis in this study, the researcher employed the research-question approach, which enabled the researcher to clearly connect the research question to the findings by using it to organise and analyse the data. The data generated was separated into phases, and each phase was utilised to answer a specific research question or two, as discussed above in Section 4.8. This further ensured that the data analysis was focused on addressing the research questions and accomplishing the objectives of this study. The researcher was also able to check for consistency and inconsistency by comparing results from other sources using this strategy. This enabled segregation of data from multiple sources and determined the significance of any discrepancies or inconsistencies that arouse.

The method that the researcher used to analyse the data is Grounded Theory. Glaser and Strauss developed Grounded Theory in the 1960s. It emphasises the development of theories through data generation and analysis (Glaser & Strauss, 1967). Deductive reasoning, which compares pre-existing beliefs to evidence, is opposed to the inductive method (Thomas, 2006). The inductive analysis method was used to analyse the data. Braun and Clarke (2006) assert that thematic analysis emerges as a primary tool for inductive qualitative data analysis. The researcher began by avoiding preconceived theories and analysing only the transcribed data generated by the study. This ensured that any theories generated was grounded in the data emerging from the study, rather than preconceived by the researcher. The researcher used the inductive method to analyse the data, which aligned with Grounded Theory. The semi-structured interview sessions were voice-recorded and transcribed verbatim using the Otter.ai app. The transcripts were compared to identify potential ideas, concepts, and elements that emerged from participants' social interactions.

The different ideas, concepts, and elements was coded in Nvivo, as mentioned above, to determine the themes. The term, phrase, or symbolic meaning given to the data segments is known as coding. Activities, occasions, tactics, participant viewpoints, or circumstances can all serve as codes. The coded data were segmented and grouped into themes. Similar themes were further grouped into subthemes, which was used to generate theory (McMillan & Schumacher, 2014). The researcher further used open coding to read through the transcripts, create summaries of ideas, and verify whether the themes that emerged from Nvivo and the researcher's reading of the data were similar. The researcher examined the data multiple times to gain a sense of the whole, and then only was the data be coded.

4.9 Ethics in Qualitative Research

The focus of ethical considerations is to determine what is ethically acceptable and unacceptable when interacting with participants during data generation (McMillan & Schumacher, 2014). According to Adu-Gyamfi and Okech (2010), a study must not be susceptible to violations such as deception or breaches of confidentiality, nor should it create a risk of injury to participants or the general public. Before starting the data-generation process, ethical clearance from various departments was sought. Permission to enter the field (Appendix 1) was granted by the appropriate authorities as follows: first, ethical clearance was obtained from the University of KwaZulu-Natal (Appendix 2). Permission to conduct the study was further obtained from the following sources: The Department of Education, which granted consent to conduct research (Appendix 3); the ten school principals (Appendix 4), who are the gatekeepers of the selected schools; and the ten participants involved in the study (Appendix 5).

The names of the participants and the research sites were disguised using pseudonyms to maintain confidentiality (Bos, 2020). According to Han (2017), pseudonyms was necessary in this context to protect participants' identities and the research site's privacy; hence, participants was given fake names. Ten teachers from 10 different schools participated in this study. The participants were informed in writing regarding the following: their right to anonymity, their right to withdraw at any stage without prejudice, and their right to decline certain questions. Additionally, non-malfeasance was adhered to guarantee that the study did not result in damage (mental, bodily, or psychological) (Arifin, 2018); hence, the researcher made sure that the participants were informed in advance of the potential cognitive and emotional damage that they may feel, such as frustration, anger, shame, or incompetence.

The data retrieved from the study is protected in the following ways and according to the guidelines set out by McMillan and Schumacher (2014): the data, in the form of written documents collected through semi-structured interviews and questionnaires, is kept under lock and key in my supervisor's office. The data stored on my computer system will be deleted. The data recorded on written documents will be shredded. The data stored on a flash drive will be deleted after five years. To provide feedback to each participant, a copy of the interview transcript was provided, and participants were able to verify that the recordings accurately reflected what transpired during the interview. The researcher made a copy of the finished thesis available to participants upon request, and a presentation of the findings from this research will occur at a workshop.

4.9.1 Trustworthiness of Data

The researcher used the following strategies to determine the study's authenticity and trustworthiness: credibility, transferability, dependability, and confirmability (Creswell, 2014; Lincoln & Guba, 1985). To enhance credibility, the researcher conducted member checking. The completed interview transcripts were handed to the participants for review (Creswell, 2014). This ensured that the interview transcript accurately reflected what actually transpired during the interview (Creswell, 2014). The researcher used bracketing to assess the study's credibility; this ensured that the researcher was conscious of personal bias and any potential prejudice that arouse during the study (Creswell, 2014). Transferability was achieved by ensuring an audit trail of the data-generation instruments was maintained (Stahl & King, 2020). Dependability was achieved through the use of member checking as discussed above (Birt et al., 2016). It also assisted the researcher by reducing any potential bias encountered during engagement with the participants (Delve et al., 2023). The reliability of the retrieved data were further enhanced, as the selected participants were already teaching C&R; hence, they were thinking critically. This enabled the researcher to link the data to its source. The researcher confirmed the study's confirmability through regular consultation with supervisors, sending all draft copies of the study to them for scrutiny, and preserving and maintaining all audit trails used during the study.

4.10 Conclusion

This chapter outlined the research strategy and methodology of this qualitative case study, which aimed to understand teachers' experiences in implementing the C&R curriculum and adapting it to best suit the school's needs. The research strategy and techniques that underpin the study, locating it within the qualitative interpretative paradigm and case study approach, were also examined. The various data-gathering tools employed, such as questionnaires, interviews, collages, workshops, focus group discussions, and reflective questionnaires, were explained. Each of these methodologies supplied unique and complementary viewpoints, increasing the credibility of the findings through crystallisation. The chapter also addressed reliability and ethical considerations, ensuring that the study complied with academic guidelines. Finally, the methodological approach established a consistent and dependable platform for investigating teachers' lived experiences with applying the C&R curriculum. The following chapter will present the data generated by these operations.

CHAPTER FIVE – PART A: THE DATA PRESENTATION LANDSCAPE

5.1 Introduction

The previous chapter outlined the research methodology adopted in this study. This chapter presents, analyses, interprets, and discusses the findings of the first and second research questions: 1*) What are teachers' current experiences of the implementation and diffusion of C&R curriculum in primary schools? 2) Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum?* Data for the first two research questions were generated through questionnaires, collages and semi-structured interviews with ten teachers involved in teaching C&R. The chapter is structured in two parts. Part A provides an overview of the data-generation process used to answer research questions one and two. It begins with a presentation and discussion of the findings. This section explores teachers' experiences with implementing the C&R curriculum before they participated in the workshops. Part B shifts the focus to changes observed after the workshops. It examines whether participants' perspectives evolved and how they applied the knowledge and skills gained to adapt the C&R curriculum to the unique contexts and needs of their schools, thereby addressing the third research question. The findings in this chapter present teachers' experiences with implementing the C&R curriculum and non-digital pedagogical approaches (unplugged) to teach the C&R curriculum before they participated in the workshops.

5.2 Overview of the Data-generation Process

The study began with one-on-one interview sessions, followed by the display of their collages and a discussion of the meanings they attached to the pictures and the words. The meanings participants associated with each image are listed below, along with their corresponding themes. During the interview and collage-making sessions, three themes emerged from the participants' data. The themes and discussions that emerged from the collages will corroborate those from the one-on-one interviews and will be presented in depth in Section 5.2. The researcher also extracted parts of the individual collages that relate to specific themes and synchronised them with themes that emerged from the one-on-one interviews. Each collage is displayed below.

Figure 5.2 (a)

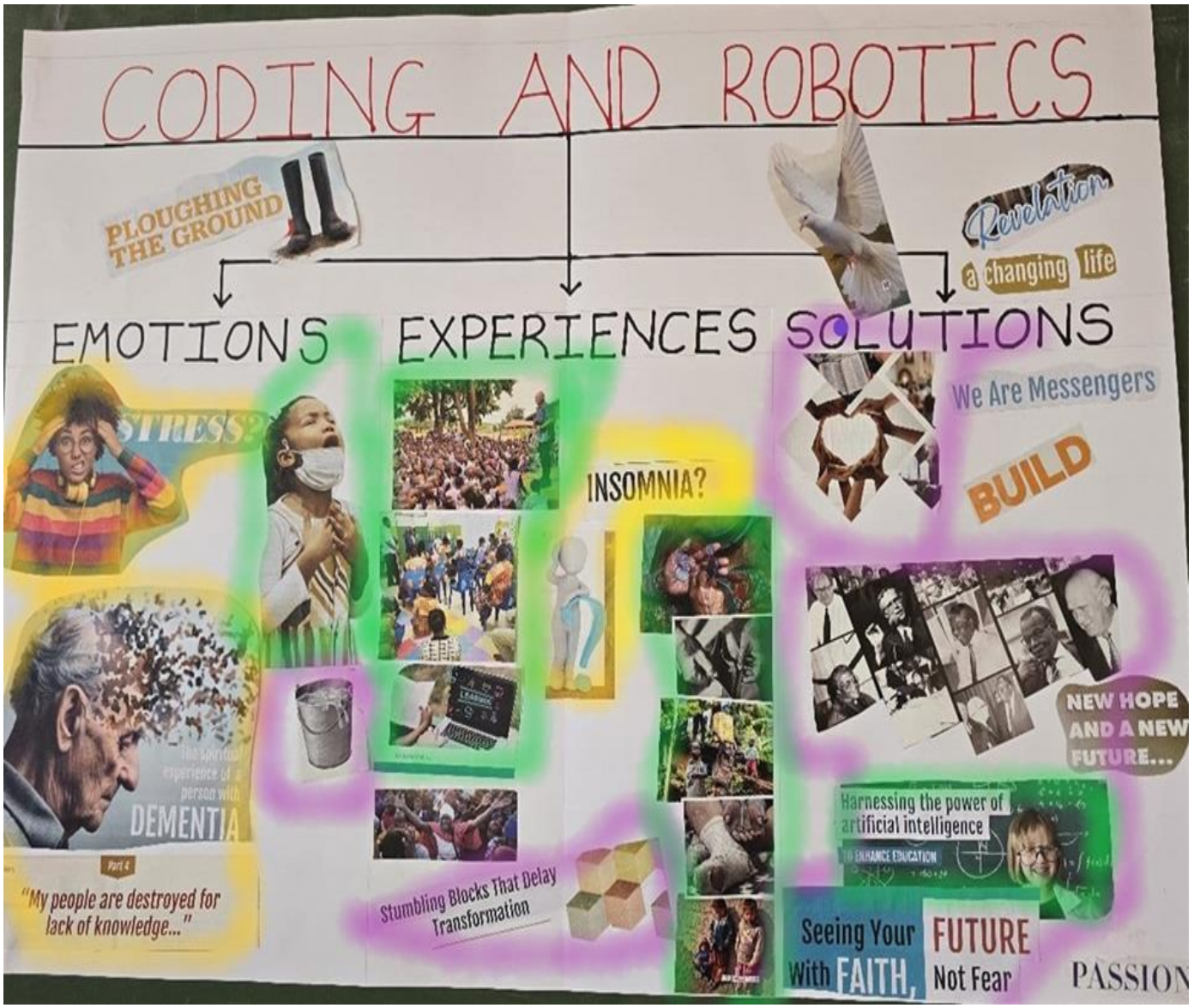
Collage One

Note. Collage One was designed by Participants 1,3, and 6.

Two of the three participants were teaching in quintile 2 schools, and one was from quintile 5. The participants did not know each other before designing the collages. The themes that emerged from this collage are discussed in Section 5.4.

Figure 5.2 (b)

Collage Two

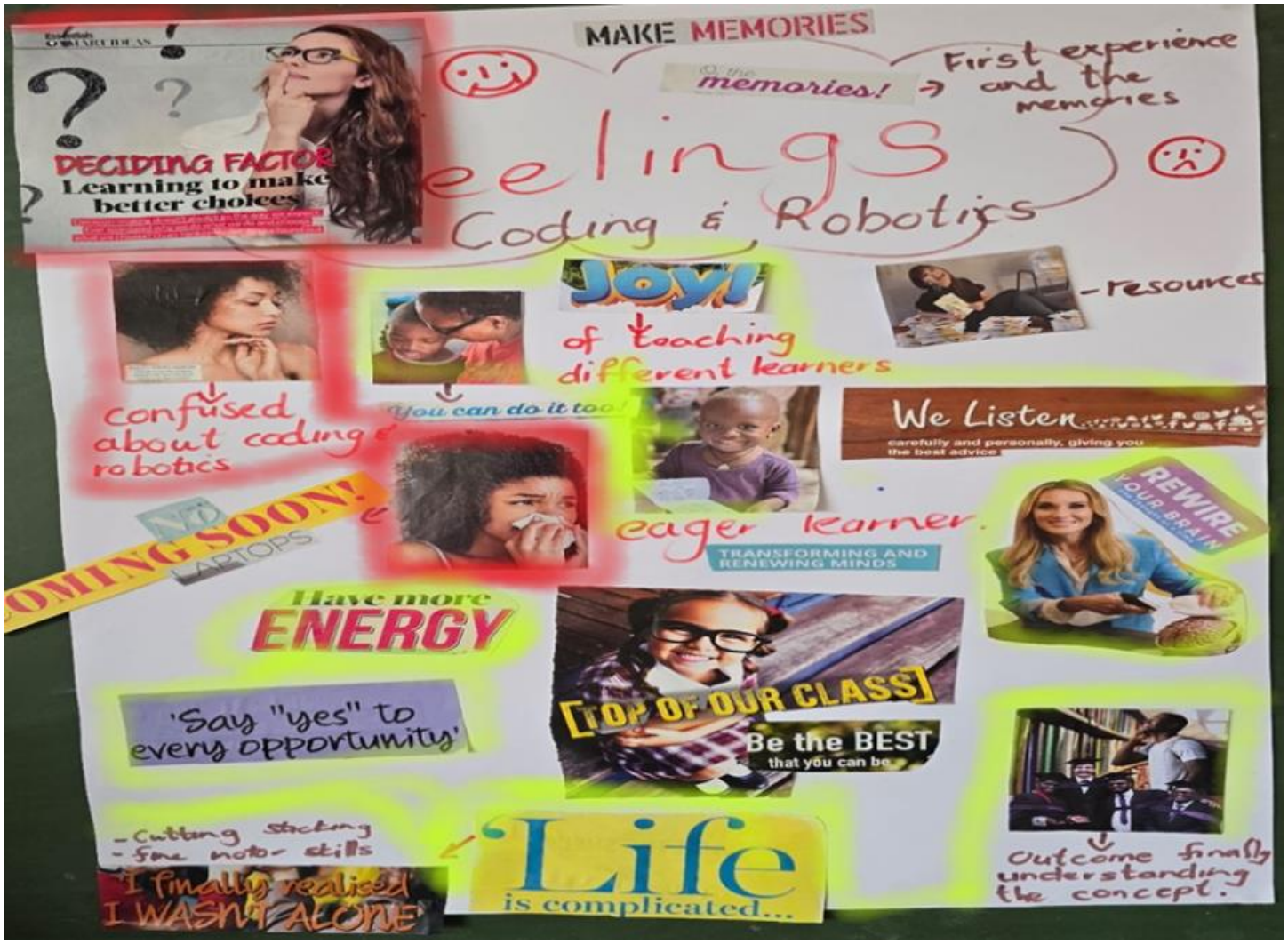


Note. Collage two was designed by Participants 4, 7, and 10.

One of the three participants was teaching in a quintile two school, one was from a quintile three and one was from quintile five. The participants did not know each other prior to designing the collages. The themes that emerged from this collage are discussed in section 5.4.

Figure 5.2 (c)

Collage Three



Note. Collage three was designed by Participants 2, 5, 8, and 9.

Two of the four participants were teaching in quintile four schools, one in quintile five, and one in quintile two. The participants did not know each other prior to designing the collages. The themes that emerged from this collage are discussed in Section 5.4.

5.3 Unpacking the Data into Themes and Subthemes

The study utilised three data-collection methods - questionnaires, one-on-one interviews, and collages - to answer research questions 1 and 2. Guided by the methodological approaches outlined in Chapter Four and to address the study's research questions, the written notes, collages, and audio recordings of the interviews were captured and transcribed using the programs TurboScribe and Otter.ai. The collected data were used to

develop themes and subthemes. The themes and subthemes that emerged were derived utilising a program called Nvivo, as mentioned in Chapter Four. The researcher also compared the themes that emerged from Nvivo with those identified when reading and re-reading the data to verify their accuracy. The researcher was able to add, support, and spot differences in the generated data by using participant-provided verbatim statements and by comparing and collaborating them with the collages and the questionnaires (Chowdhury & Shil, 2021).

In implementing thematic cross-case analysis, three broad themes emerged, each with corresponding subthemes. Subthemes were derived from these overarching themes in a corresponding manner. The researcher derived inspiration from Dawadi (2020) when analysing the data collected from research participants. (Dawadi, 2020) emphasises an inductive approach to analysis, which generates themes from the data itself without giving much thought to patterns found in other studies and the literature. The presentation of the overarching themes and subthemes shown below is based on an inductive analysis approach, as discussed in the previous chapter. These themes and subthemes sought to answer questions One and Two of the research study, as mentioned before. The themes and corresponding subthemes are further elaborated and presented as follows:

Table 5.3(a)

Themes and Corresponding Subthemes that Emerged from the Data Generation Phase

Sub-chapter	Theme	Corresponding Subthemes
5.4	Emotions	5.4.1) Intimidation and frustration over the implementation of the C&R curriculum 5.4.2) Perseverance and hope
5.5	Stumbling Blocks that delay transformation	5.5.1) Ineffective Training 5.5.2) Group work in an overcrowded class size 5.5.3) Lack of inclusivity and accessibility within the curriculum
5.6	Bridging the Gap: Integrating Unplugged to Address Nature Deficit and Technological Constraints	5.6.1) Lack of technological resources 5.6.2) Unplugged 5.6.3) Nature deficit in learners

Note*:* Author-generated table.

To avoid confusion when presenting data from the three separate data generation methods, the researcher assigned a pseudonym to each participant. This was also used to protect participant privacy. Each participant was assigned a unique identifier composed of letters and digits; for example, participant 1 will be referred to as PI-1 when presenting data from the one-on-one interviews and as PC-1 when presenting the same

participant's data in the collages. The 'PI' prefix refers to participants from the one-on-one interviews, whereas the 'PC' prefix refers to participants from the collages.

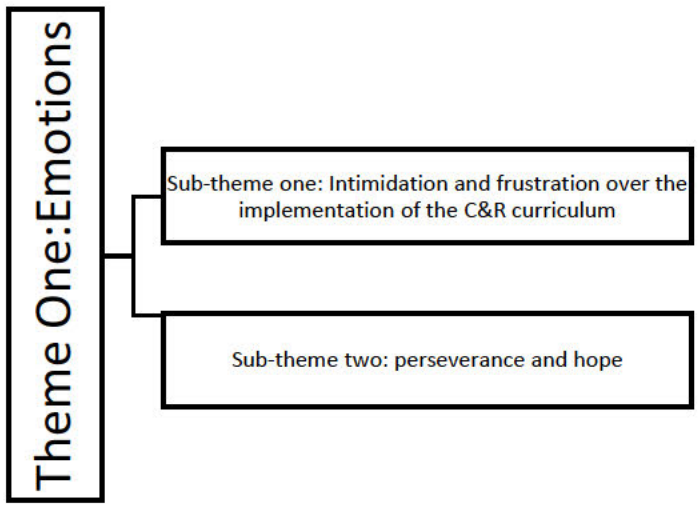
5.4 Theme One: Emotions

To answer the research question: What are teachers' current experiences of the implementation and diffusion of the C&R curriculum in primary schools? The following theme emerged: Emotions. The majority of participants expressed their experiences through a range of emotions. Participants expressed negative emotions due to intimidation and frustration towards implementing the C&R curriculum. Subsequently, those participants were from schools ranked in quintiles 2, 3, and 4. At the other end were participants from quintile five schools; they expressed positive emotions about implementing the C&R curriculum.

The subthemes that emerged from the main theme above (Emotions) are discussed below and represent participants' opposing views on implementing the C&R curriculum, ranging from intimidation and frustration to perseverance and hope. The subthemes emanated from the following data-gathering tools: one-on-one interviews, collages, and questionnaires. Below is a diagrammatic representation of the theme and subthemes.

Figure 5.4. (a)

Presentation of the Theme and Corresponding Subthemes



Note: Visual representation created by the author

5.4.1. Subtheme One – Intimidation and Frustration over the Implementation of the C&R Curriculum

Participants expressed feelings of intimidation and frustration during the implementation of the C&R curriculum. This was because they viewed their old age as a barrier to fully understanding and implementing the innovation, and they had difficulty balancing their work and personal life. These subthemes are further discussed below.

5.4.1.1 Old Age as a Barrier

The average ages of participants by quintile are: quintile 5: 41.33; quintile 4: 32; quintile 3: 43.5; quintile 2: 53. Participants in lower quintiles (quintile 2) have a higher average age than those in higher quintiles in this dataset. The implementation of the C&R curriculum has elicited significant emotional responses from teachers, notably feelings of intimidation and frustration. A prevalent concern among older teachers is that their age acts as a barrier to effectively integrating this curriculum into their teaching practices. As the educational landscape becomes increasingly dominated by advanced technology, this perception exacerbates feelings of intimidation and frustration, particularly in adopting innovative pedagogical approaches. Older participants expressed greater apprehension about their technological competence than their younger counterparts. The age demographics of the participants, as detailed in Table 1 above, provide critical context for these findings. This data, derived from the questionnaire responses, was further elucidated through one-on-one interviews and underscores the influence of age on teachers' perceptions and attitudes towards C&R.

During the one-on-one interviews, PI-3 expressed feeling intimidated by the introduction of C&R due to a lack of the necessary knowledge to implement them effectively. PI-3 attributed the lack of knowledge to old age. This intimidation and frustration were expressed as follows:

> *I feel lost sometimes. I am too old to teach this new subject, C&R. This subject is for the techno-savvy younger teachers. I am old school.*

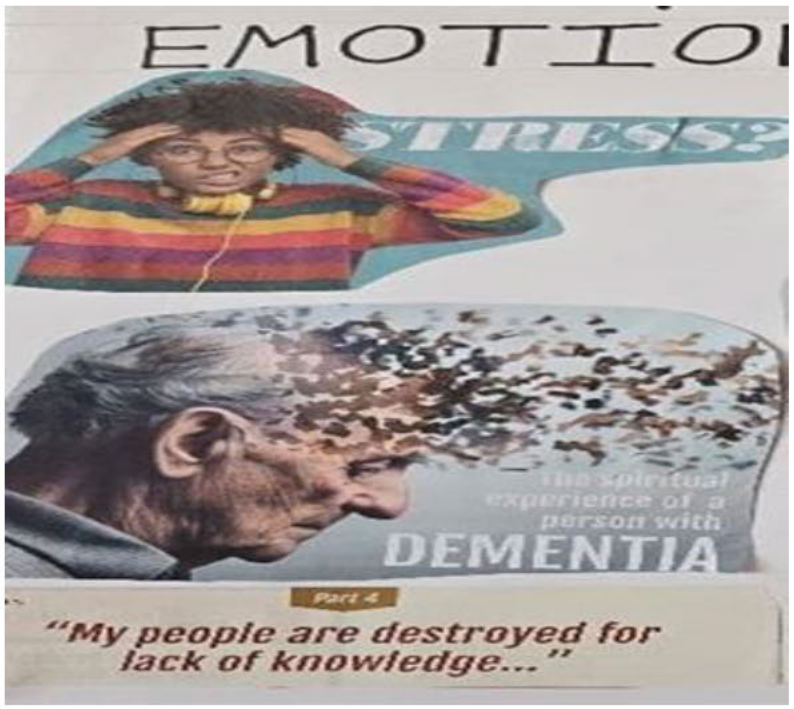
According to recent research by Al-Mukhaini et al. (2021), elderly teachers frequently distrust their own ability to use digital tools. They believe that they are too old to learn a new subject. PI-6 had this to say:

> *I feel intimidated because this is something new to me. Now, I have to seek out more information on how to teach it properly because my school cannot assist. As a teacher, I must first understand it thoroughly to implement it correctly. I am too old for this.*

Participants expressed a shared concern about the challenges of learning new subjects, particularly given their age and prior knowledge. Participant 7's statement highlights the anxiety and disorientation that can arise from being introduced to unfamiliar curricula, which is visually represented in the collage through the image of a distressed individual.

The accompanying caption underscores the emotional toll of this experience, suggesting that the participants' limited understanding of the subject matter led to significant distress. The image in Figure 5.4.1(a), extracted from Collage Two, serves as a poignant illustration of those feelings.

Figure 5.4.1.1 (a)



Note. Picture extracted from Collage Three illustrating participants' distress

The collage designed by PC-10 visually represents the emotional distress associated with acquiring new technological skills later in life. The participant's contention that learning new subjects is inherently arduous is supported by the challenges posed by the rapid pace of technological innovation. The difficulties encountered in adapting to these changes can be debilitating, resulting in feelings of cognitive overload and frustration. The image of the woman clutching her head serves as a powerful metaphor for the stress participants experience. At the same time, the portrayal of the older man with dementia underscores the perceived cognitive consequences of lacking proficiency in this domain.

The caption "My people are destroyed for lack of knowledge" underscores the sense of despondency and frustration that can arise from feeling disenfranchised by technological progress.

Figure 5.4.1.1 (b)

Note. Image extracted from Collage Two, designed by participant 4.

The introduction of C&R into the C&R curriculum was met with anxiety and stress among teachers, as evident in the images extracted from Collage two (Figure 5.1.4(b)) above. The image features a ghost-like figure with the caption "INSOMNIA?", suggesting that teachers are losing sleep over concerns about teaching this new subject. This sentiment was echoed in the collage, implying that teachers were intimidated by the prospect of teaching C&R. The image of a ghost, often associated with fear and uncertainty, reinforces this interpretation.

Figure 5.4.1.1(c)

Note. Image designed by PC-3 and is extracted from Collage One.

The text "Displaced, Destitute, & Traumatised" suggests a state of severe distress or hardship, conveying a sense that participants are overwhelmed and negatively affected by the C&R curriculum. These feelings are metaphorically linked to the challenges faced when learning or implementing these technologies. Participants new to C&R felt displaced from their comfort zones, lacking the necessary skills, and traumatised by the complexity or the pressure to perform. The image also conveys a sense of helplessness and fear of being replaced by younger teachers. Research by Hsu et al. (2022) supports this finding, suggesting that older teachers may struggle to effectively utilise digital instruction due to a lack of confidence in their abilities.

5.4.1.2 Balance Between Work and Personal Life

Participants' frustrations stemmed further from the implementation of the new subject, which they described as highly time-consuming, given that teachers are already burdened with multiple administrative responsibilities. Participants reported struggling to balance the new subject with their personal lives because they had to work long hours after hours. Participants face many obstacles when incorporating into the C&R curriculum, chief among them being the additional time commitment needed to prepare and present this novel material properly. Participants struggle to strike a balance between their professional and personal obligations since they are already overburdened with administrative responsibilities. The participants' Feedback as reported during the one-on-one interviews.

According to PI-10.

> *Preparing and planning the lessons to teach C&R takes a lot of time. I can't ignore my obligations to my family.*

These feelings highlight the conflict between work and personal obligations, a prevalent issue among teachers adjusting to new curricular requirements. Participants expressed frustration with the demands of lesson preparation, allocating sufficient time for instruction, managing paperwork, and planning, which further adds to the disappointment of integrating C&R into the C&R curriculum. PI-6 states:

> *Teaching C&R is extremely taxing with the limited time we have. On top of our teaching responsibilities, we also have families and personal lives. Adding a new subject makes it even more overwhelming because there's so much to cover and prepare.*

PI-9 shares a similar sentiment to PI-6, stating that while we are implementing C&R as a new subject, the teacher feels frustrated by the additional stress and paperwork it adds to their already stressful job. PI-9 further states that the introduction of C&R is causing extra stress among teachers because they lack support from their SMT. PI-9 had this to say:

> *We're really so stressed out. We are introducing Coding, which is a different language altogether. It's frustrating for us teachers to teach this new subject because it's not simple and straightforward, and there is no help from the principal nor department heads.*

Participants' Interpretations using collages related to feelings of stress and frustrations are displayed below:

Figure 5.4.1.2 (a)

Note. Image extracted from Collage One and designed by PC-6.

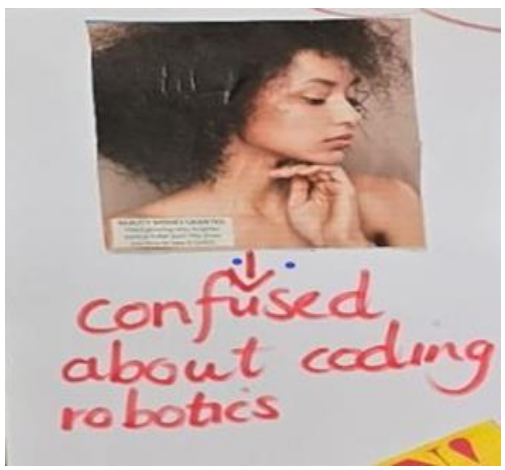
The image displayed shows a woman biting her fingernails, with a facial expression that exudes stress, confusion, and frustration. The image shows that participants feel overwhelmed and stressed out when implementing the C&R curriculum. This frustration and intimidation stem from both contextual and emotional factors, as mentioned above.

Figure 5.4.1.2 (b)

Note. Image extracted from Collage One and Designed by PC – 3.

This image visually represents the emotional toll the new educational reform has taken on teachers. The image depicts a man with his hands on his head, conveying distress and frustration, reflecting the emotional state of teachers struggling to implement a new C&R curriculum. The man's posture and facial expression suggest feelings of overwhelm, anxiety, and possibly even despair. This image indicates that introducing C&R into the C&R curriculum has caused significant stress for teachers.

Figure 5.4.1.2(c)



Note. Image pasted by PC-9 of Collage Three.

The image visually conveys the participant’s confusion. The confusion stemmed from experiences that left them feeling unsure, such as the implementation of the C&R curriculum and the paperwork burden. The above concerns were supported by research conducted by Bimenyimana and Hesbon (2024), who found that when teachers have too much work, it becomes harder for them to teach the C&R curriculum effectively. Similarly, Haque and David (2022) showed that a heavy workload makes it difficult for teachers to balance their responsibilities, leading to stress and lower teaching quality. These studies highlight the need for better support and resources to help teachers manage new subjects without feeling overwhelmed.

The feelings of frustration and intimidation align with findings from Gavrilas and Kotsis (2024), who explored teachers' perceptions of the benefits and challenges of integrating robotics into the primary curriculum. The study revealed that while teachers generally hold positive attitudes toward incorporating robotics into teaching, they also recognise the need for professional development to implement these tools effectively. This highlights the importance of equipping teachers with the necessary training and resources to ensure successful integration.

5.4.2 Subtheme: Perseverance and Hope

The perseverance and hope teachers exhibit during the implementation of the C&R curriculum play a pivotal role in shaping learners' mind-sets towards this subject. The intricate and iterative nature of C&R necessitates trial and error, and often, failure is an integral component of the learning process. Teachers must adopt a growth mentality that fosters the value of perseverance in the face of challenges, particularly in the South African context, where resilience and technical expertise are essential for innovation and adaptation in a rapidly evolving technological landscape (Motala, 2021).

Hope catalyses teachers to inspire learners to envision a future in which they can effectively utilise C&R to address practical challenges. The integration of C&R into the C&R curriculum aims to promote creativity, innovative thinking, and problem-solving skills, all of which are vital for producing a workforce equipped to thrive in the expanding technology industry. In the South African context, where financial and social struggles are prevalent, teachers who instil hope via C&R can empower learners to overcome obstacles and prepare them for future careers in technology (Ohei et al., 2023).

When teachers persevere and maintain hope as they implement the new C&R curriculum, they can create a nurturing classroom environment that encourages learners to explore the vast potential of C&R. Participants expressed divergent views of the C&R curriculum, with some finding it frustrating and intimidating as presented. In contrast, others felt hopeful that they would overcome any difficulties and persevere. The subtheme of perseverance and hope, as illustrated in the collages, is discussed below.

Figure 5.4.2(a)

Note. Image extracted from Collage One and Designed by PC-1.

The image depicts a peacock, its vibrant feathers a symbol of hope for 's future, emphasising the importance of perseverance in the face of challenges. The peacock is often associated with beauty, pride, and resilience. Its stunning plumage represents the beauty and complexity of C&R. The image suggests that despite the difficulties encountered in these fields, one can emerge stronger and more vibrant, much like the peacock's majestic appearance. The peacock's ability to thrive and display its vibrant feathers despite potential challenges serves as a metaphor for the potential for growth and success in C&R.

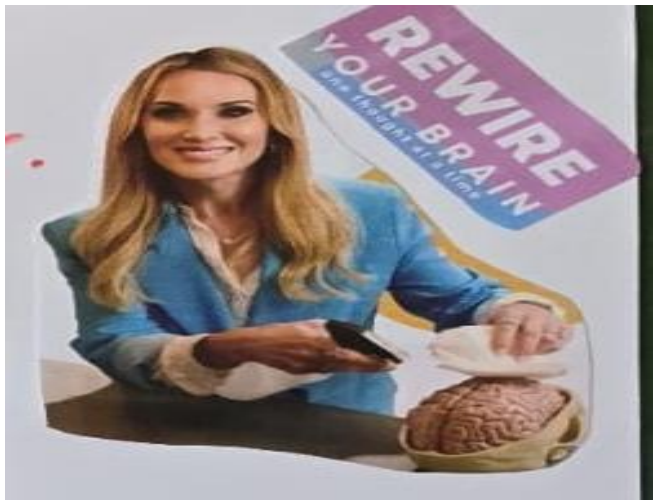
Figure 5.4.2. (b)

Note. Image extracted from Collage One and pasted by PC-1.

This image was interpreted as a powerful metaphor for perseverance and determination.

The image suggests that pursuing knowledge and skills in C&R is not merely a technical endeavour but a calling that requires dedication and passion. Furthermore, the journey of learning and growth is not always easy, but it is through persistence and resilience that one can break through barriers and achieve success. The caption "Don't take your calling for granted" is superimposed over the image, serving as a poignant reminder of the importance of appreciating and valuing one's purpose or vocation as a teacher.

Figure 5.4.2. (c)



Note. Image extracted from Collage Two and designed by PC – 4.

The image presents a woman sitting at a table, engaged with a smartphone and a brain-shaped object, accompanied by the text "REWIRE YOUR BRAIN". This visual representation is a metaphor for cognitive adaptation and the need to evolve one's mind-set to implement the C&R curriculum effectively. To effectively teach C&R, teachers must be willing to challenge their existing pedagogical approaches and embrace new methodologies. The concept of "rewiring" one's brain is particularly pertinent in this context, underscoring the importance of cognitive flexibility and the ability to adapt to new information and technologies. The image further suggests that the process of rewiring one's brain is not merely a passive reception of new information but an active engagement with the subject matter. The woman in the image is shown actively using her smartphone, symbolising the interactive and dynamic nature of learning C&R.

Figure 5.4.2. (d)

Note. Image extracted from Collage Three and Designed by PC – 8

The collage designed by PC-8 presents a compelling vision for implementing the C&R curriculum. By emphasising perseverance, hope, and passion, the collage serves as a powerful reminder of the need for a positive, resilient mind-set in the face of challenges and uncertainties. As

educators and learners embark on this journey, they must be willing to harness the power of artificial intelligence, approach the future with faith, and cultivate a deep passion for the subject matter.

The collage can be interpreted through the lens of perseverance and hope in the context of implementing the C&R curriculum. The emphasis on "harnessing the power of artificial intelligence" and "seeing your future with faith" implies that educators and learners must be willing to persevere through challenges and uncertainties. By doing so, they can unlock the full potential of the C&R curriculum and achieve their goals. The overall message of the collage is one of hope and optimism. It encourages participants to approach the future with confidence and faith, rather than fear or doubt. This hopeful outlook is essential for creating a supportive and inclusive learning environment. Participant Feedback as Reported during the one-on-one interviews is displayed below:

PI-4 also corroborated the experiences as reflected in the collage above with the one-on-one interviews and had this to say:

> *While there were initial challenges with implementing the C&R curriculum, we were able to view it positively by changing our mind-set from cannot to- can do! We are very hopeful of what C&R is going to do for our learners, but I believe it must begin with us individually*.

The rewire of your mind, as expressed above, is an important consideration for change from a fixed to a more open mind-set. An open mind-set is more accepting of exploring the new curriculum. Teachers must change their perspective by rewiring their thoughts to believe they can persevere and succeed despite challenges. PI-8 shares that implementing the C&R curriculum at school was very easy due to proper resourcing and sufficient support from SMT. Participant 8 shares feelings of hope and perseverance in the one-on-one interview sessions. PI-8 had this to say:

> *We are able to properly implement the C&R curriculum at school due to the resources that our school has. We have internet access and a lovely computer lab. Learners are thriving, and we get support from our SMT; e.g. if I require more resources, my DH takes the liberty of downloading it for me and giving it to me.*

To answer the question, what are teachers' experiences implementing the C&R curriculum, the theme that emerged was Emotions, as stated above. Consequently, the subthemes which opposed each other were intimidation and frustration over the implementation of the C&R curriculum and hope and perseverance. Participants who taught in lower quintile schools (quintiles 2, 3, and 4) shared experiences of frustration and intimidation, while participants who taught in quintile 5 schools shared experiences of hope and perseverance. s

The literature supports the experiences of participants who teach in higher quintile schools; as Köhler (2020) states, teachers from higher quintile schools are more likely to have better credentials, more teaching experience, greater self-assurance, and better job satisfaction. Additionally, they are more likely to have been trained to support children with learning disabilities and to teach in classrooms where all

learners have adequate resources. This further corroborates the study by Jones (2021), who assert that the school quintile significantly influences how C&R is implemented: teachers from low quintile schools tend to view its implementation negatively, while teachers from higher quintiles have a more positive experience.

5.5 Theme Two – Stumbling Blocks that Delay Transformation

In responding to Research Question one, which is: What are teachers' current experiences of the implementation and diffusion of C&R curriculum in primary schools? Their experiences emerged as stumbling blocks that delay transformation. Within this study's context, "stumbling blocks" refer to difficulties or impediments that hinder efficient teaching of the C&R curriculum. These stumbling blocks relative to implementing the C&R curriculum can seriously impede learner engagement and educational progress (Smith & Kearne, 2021).

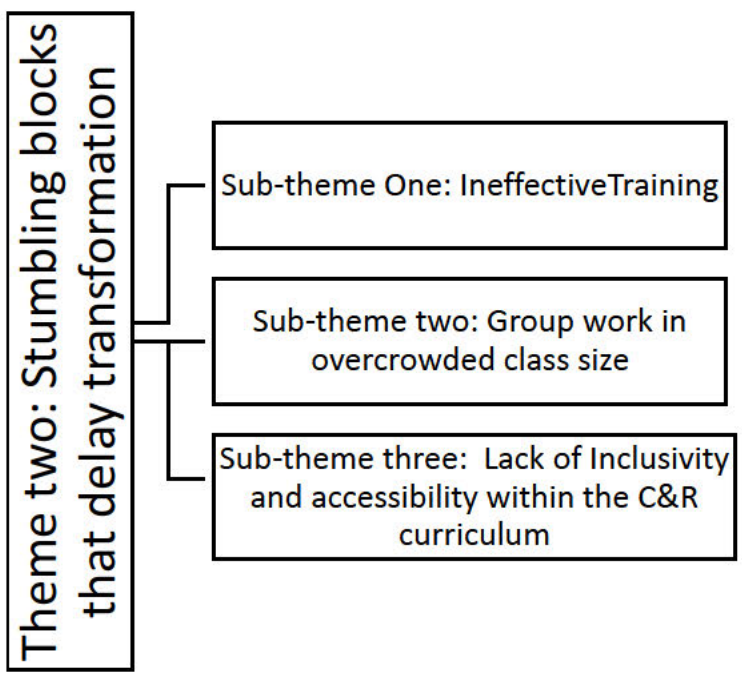
Figure 5.5(a)

Note. Stumbling Blocks that Delay Transformation – Collage Two.

Stumbling blocks that delay transformation emerged as theme two in this study, and the corresponding subthemes are: ineffective training, group work in overcrowded classes, and a lack of inclusivity and accessibility within the C&R curriculum.

Figure 5.5 (b)

Presentation of the Theme and Corresponding Subthemes



Note: Visual representation created by the author

5.5.1 Subtheme One: Ineffective Training

Of the ten participants interviewed, eight reported receiving training from the DBE in C&R. Of those eight, seven reported struggling to understand it. This was primarily due to the overuse of computer jargon, which many teachers were not familiar with; hence, training emerged as a subtheme. Participants PI-4, PI-6, PI-9, and PI-10 expressed similar sentiments, stating that the training provided by the DBE was inadequate, too advanced, and characterised by technical language that was difficult to comprehend. They emphasised the need for training tailored to teachers' needs, with trainers who can communicate complex concepts in a simple yet clear and concise manner. The participants' feedback, as reported during the one-on-one interviews, is displayed below:

PI-4 states that training should be quality-driven, not just done for the sake of it. Some teachers may not be technologically proficient, and the DBE's workshops were confusing because they had professional IT specialists as facilitators; as a result, the computer jargon they used was difficult to understand. The suggestion is that training must be delivered by trainers who teach in a manner understandable to the average teacher. PI – 4 had this to say:

> *You should not do training just to say the training is done. Some teachers also don't have a very high understanding of technology as well. It was very confusing for us to even understand because these trainers were professional IT specialists. We didn't understand the jargon they used.*

PI-6 reaffirmed what PI–4 stated above, namely that the Department's training was too advanced, of little benefit, and that the majority of the teachers who attended the workshop also expressed the same feelings to her.

> *The Department is training us, but they send people to train us who we don't understand their use of language since they are advanced. We didn't understand the training. I was lost. We went for one week. They spoke so fast and expected us to just go with their flow.*

PI-9 concurred with PI–4 and PI-6 that the training provided by the DBE was a waste, as the instructors were too fast for experienced technicians, making it difficult for them to understand and learn anything.

> *I was also lost the first time that I attended the workshop, and I felt it was such a wasted day because we learnt nothing. The first time that we went for the course, these people that were teaching us were technicians, on a different level. I couldn't understand much, to be quite honest.*

PI-10 found the DBE training to be too fast-paced, rendering it a waste of time. PI – 10 had this to say:

> *We could not understand. They were going too fast. And we were also lost. So that is why I'm saying I did not learn anything at all from that first experience.*

PI-4 stated that there were challenges during the DBE training that rendered it useless and added to their confusion; these were as follows:

> *There was load shedding that happened for two hours, so the projector was off, and then the laptops they asked us to bring was dead. We sat confused while the facilitator spoke to us using computer jargon.*

Effective training is important; teachers need both technical training and subject-specific pedagogical understanding to teach the C&R curriculum effectively. Participants' experiences with the DBE training were that it was ineffective, too fast-paced, and that the facilitator's jargon was not at the level of the teachers' technical understanding. Research shows that teachers often lack sufficient technical expertise, making it difficult to teach these cutting-edge subjects (Hsu et al., 2019). This results in a disconnect between teaching methods since teachers lack the necessary training to handle the intricacies of robotics platforms and coding languages (Zivanayi & Malinga, 2025). This problem is exacerbated by the lack of a well-organised professional development programme, as shown in the data above, which deprives teachers of the support they need to acquire these vital abilities (Chaka & Mjela, 2025).

Teacher training in implementing the C&R curriculum is vital and shapes their experience with it. Regarding the number of participants who received training in C&R curriculum, the questionnaires indicated that eight of the ten participants received training. One participant was from Quintile 2, one from Quintile 3, three from Quintile 4, and three from Quintile 5. This is in keeping with Moyo (2024), who states that teachers in high quintile schools are more likely to acquire specialised training in C&R.

Conversely, schools in lower quintiles might not have the resources or support necessary to offer specialised training, leading to a more negative teacher-training experience during implementation of the C&R curriculum (Pillay & Mohammed, 2024). The findings from this study revealed that even though participants from different quintiles received training, the quality of the training rendered it ineffective. In summary, teacher training must emphasise language simplification to enhance the C&R curriculum. By abandoning training based primarily on jargon and adopting a more approachable teaching approach, teachers will not only better understand the subject matter but also be better able to convey it to learners. To successfully integrate technology into the classroom, it is imperative to create an environment where teachers feel capable and secure.

5.5.2 Subtheme Two: Group Work in Overcrowded Class Size

The C&R curriculum in South Africa promotes group work among learners, as it is essential for the development of interpersonal skills – such as problem-solving, cooperation, and interaction – and technical skills (Department of Basic Education, 2020). Learners participate in cooperative learning through group work, where they can exchange ideas, solve problems together, and improve their knowledge of the C&R curriculum (Demetroulis et al., 2023). Overcrowded classrooms have a detrimental effect on group work dynamics, which, in turn, affects learning outcomes and engagement. Research indicates that teachers' capacity to facilitate group activities are weakened when class sizes are large, resulting in lower levels of learner participation and cooperation (Antoniou et al., 2024). Classroom sizes vary across quintiles. Quintile 5 has the lowest average classroom size (39.33). Quintile 3 and Quintile 2 have higher average classroom sizes (47 and 46, respectively). There is a trend of increasing average classroom size from higher quintiles (like Quintile 5) to lower quintiles (like Quintiles 2 and 3). There were opposing views on overcrowded classes, which hindered the effective implementation of the C&R curriculum regarding group work. Six participants mentioned large class sizes as a reason for learners' low participation. This element directly impacted how C&R were taught and how the learners interacted with their teacher. According to those participants, the classroom setting was unsuitable for teaching C&R, and the classroom sizes ranged from 45 to 50.

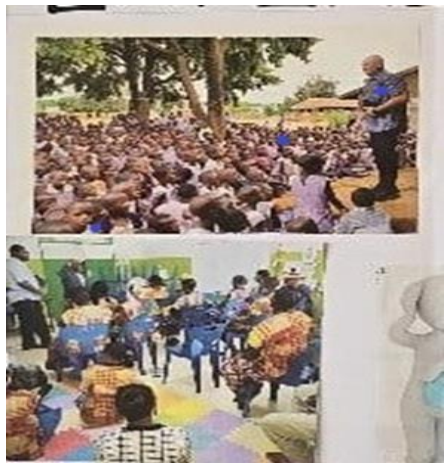
While the remaining four participants expressed opposing views, saying that classroom size has nothing to do with the effective implementation of the C&R curriculum in group settings. These participants believe that it is up to the classroom teacher to implement the C&R curriculum effectively and to be engaging and alert, managing the classroom so that learners are not distracted but are gainfully occupied and learning. The table below shows the class size for each participant's school. This information was extracted from the questionnaires. PI-10 reported that it is not easy to engage in group work due to the large classroom size. PI-6 reiterates PI-10's point, stating that it is difficult to give full attention to all the groups because the class is so overcrowded.

PI – 6 has this to say:

> *There's lots of group work that goes into teaching C&R, and our classroom size is not conducive to doing group work. The classes at my school is between 45 and 50. That makes it impossible for us to do justice to group work.*

The participants further expressed their feelings and thoughts through the collage, depicting learners in overcrowded spaces trying to learn.

Figure 5.5.2(a)



Note. Image Extracted from Collage Two by PC – 3.

The image is a collage of two photographs: a large crowd gathered in an outdoor setting and another group in a more confined space, suggesting a high learner-to-teacher ratio. The crowded scenes depicted in the image imply that the educational setting is overcrowded, making it difficult for learners to receive individualised attention. The image suggests that the large class sizes hinder the effective delivery of C&R education, as it is difficult for teachers to provide personalised instruction and guidance to learners. PI – 9 stated that the C&R curriculum must be fit for purpose within a South African context. Group work according to PI-9 is extremely difficult to achieve due to overcrowded classes and limited resources. It becomes noisy, and minimal work was ultimately achieved. Teachers are monitoring behaviour during group work rather than effectively guiding and teaching the groups. PI – 9 had this to say:

> *Group work in the C&R curriculum is extremely difficult to achieve within a South African context. I feel that the C&R curriculum must be fit for purpose, and we must be able to adapt it to our own school. I try to do that, but group work is virtually impossible. Our classes are small, and the class size is large. We can't do group work as the C&R curriculum states we should.*

While participants express that overcrowded classes hinder the effective implementation of C&R, specifically group work, research indicates the opposite. According to Köhler (2020), class size is irrelevant. Instead, it is that, until other circumstances change, class-size adjustments cannot be useful for enhancing learner outcomes. Stated differently, it appears that classroom size does not affect learner performance, whereas

other factors, such as teacher proficiency, resource availability, and a conducive learning environment, do. Studies such as those conducted by Finn and Achilles (1990) and Blatchford et al. (2011) found that smaller class sizes, typically between 20 and 25 learners are associated with improved learning outcomes, particularly in the early years of schooling. This study does not dismiss those findings; rather, it recognises that the evidence on class size is genuinely contested. What the data from this study suggests is that, within the specific context of C&R implementation in South African primary schools, teacher competence and professional confidence emerged as stronger mediating factors than class size alone a finding that is consistent with Köhler's (2020) position, whilst acknowledging that class size remains a relevant consideration in other educational contexts.

PI – 1, 4 and 5 concur with the findings of Köhler (2020) by expressing themselves through images displayed in the collage, making specific references to teamwork, the formulation of PLCs, collaborating and communicating with different teachers, and balancing the time allocated effectively. These participants believe that overcrowded classes do not hamper the effective implementation of group work; rather, it is the teachers' competence, confidence, and professional development that determine its success. The participants referred to the white dove as a symbol of hope and a changing life. PI-1 had this to say:

> *As teachers, we capacitate ourselves through professional development activities, and we understand how to deal with group work in overcrowded classes. As teachers, we are in control of our classes, and we should engage in group work with passion and not fear.*

PI – 4 had this to say:

> *My learners love working in groups and figuring out together how to solve problems and to code. As a teacher, I ensure that my learners are engaged in the lessons and that the lessons are interesting. I don't have a problem with discipline in my class, even though there are 43 learners. I am in control of my class.*

PI-5 concurs with the above, stating that you should be confident when delivering your lessons and engaging so that learners are interested and all are interacting. This is especially important for you to succeed in working in groups in large-enrolment classes.

Figure 5.5.2 (b)

Note. Image extracted from Collage Three by PC – 5

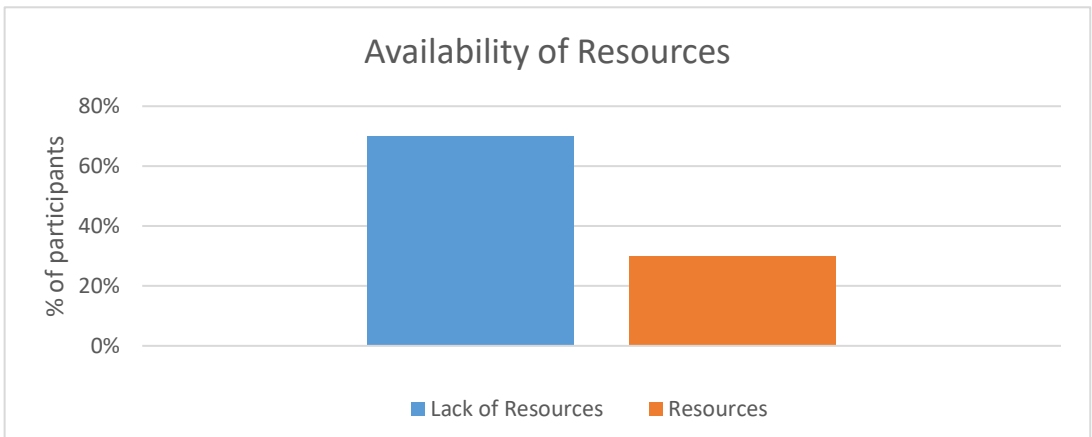
The above image depicts a child smiling confidently, with the words "top of the class" written across. Teachers who was confident and well-trained in C&R are often more engaging and effective in the classroom. These teachers are better prepared to handle large class sizes and group work.

5.5.3 Subtheme Three: Lack of Inclusivity and Accessibility Within the C&R Curriculum

The DBE (2020) aims to make C&R education inclusive and accessible to all learners, regardless of their background or competencies. Participants in this study found the above to be contrary, stating that they were unable to implement C&R effectively at their schools because the C&R curriculum is not adaptable to learners with different needs. Participants further expressed that many learners do not have access to the necessary devices or internet, and that the C&R curriculum is therefore inaccessible and not inclusive of all learners, as was proclaimed in the CAPS documentation. The lack of inclusivity and accessibility within the C&R curriculum emerged as a subtheme, as participants expressed a need for it to be inclusive of learners' varying needs and accessible to all learners. Below are two graphs that reflect information on the availability of resources (graph 5.5.3(a)) and participants' need for training to adapt the C&R curriculum (graph 5.5.3(b)).

5.5.3 (a)

Graph Revealing Participant's Availability of Resources

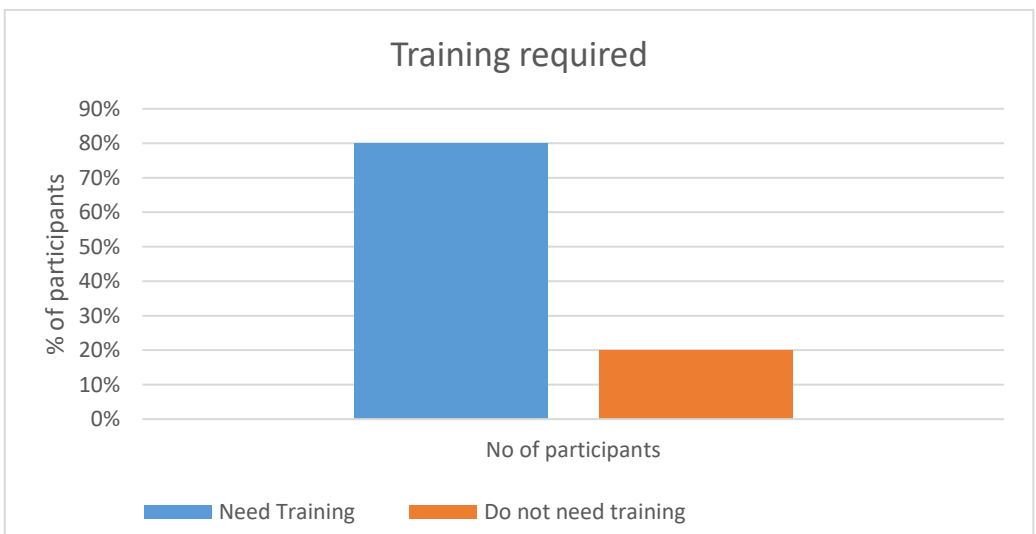


Note*:* Author-generated graph

Graph 5.5.3(a) above reflects the information that emerged from the questionnaires (Appendix 5). This information revealed that 70% of participants lacked the necessary resources and support to implement inclusive and accessible C&R lessons. Participants feel inadequately prepared to adapt this technological curriculum for diverse learners, pointing to systemic gaps in teacher training and resource allocation. See the graph below:

5.5.3(b)

Graph Revealing Participants Need for Training



Note*:* Author-generated graph

Graph 5.5.3(b) depicted above reflects that 80% of participants indicated they need training to adapt curriculum materials for learners with diverse abilities and needs. Moreover, participants report that learners from disadvantaged families face significant obstacles in obtaining C&R education due to insufficient resources, including hardware, software, and reliable internet connectivity. Participant feedback as reported during the one-on-one interviews is as follows:

PI-7 stated:

> *The C&R curriculum should cater to all types of learners, especially those with barriers, such as learners from schools that lack resources.*

PI – 9 expressed:

> *The C&R curriculum does not account for the barriers learners face. They expect all schools to be able to implement it, even if we don't have resources to do so.*

PI-3 shared the same sentiments as the above participants and had this to say:

> *There's no one-size-fits-all in the C&R curriculum. I believe that the C&R curriculum must take into consideration all types of learners and also be accessible to learners in all parts of the country.*

This aligns with the findings of Van der Merwe and Barnard (2022), who highlighted significant obstacles to fair technology inclusion and accessibility in the South African education system. The evident deficiencies in inclusivity and accessibility within the C&R curriculum are substantial issues in the South African educational system. According to the South African CAPS, curricula must foster equity by providing the same opportunities to all learners, including those with diverse learning needs (Department of Basic Education, 2020).

The C&R curriculum's uniform approach disregards the varied needs of learners, especially those with disabilities or from underprivileged backgrounds. This uniform approach opposes the inclusive education principles established in South African policy, which promote curriculum modifications to address all learners' requirements (South African Department of Education, 2021). Consequently, until the C&R curriculum and its adoption techniques are revised to enhance inclusivity by providing essential resources and specialised teacher training, inequities will persist, jeopardising the objective of equitable access to the 21st century.

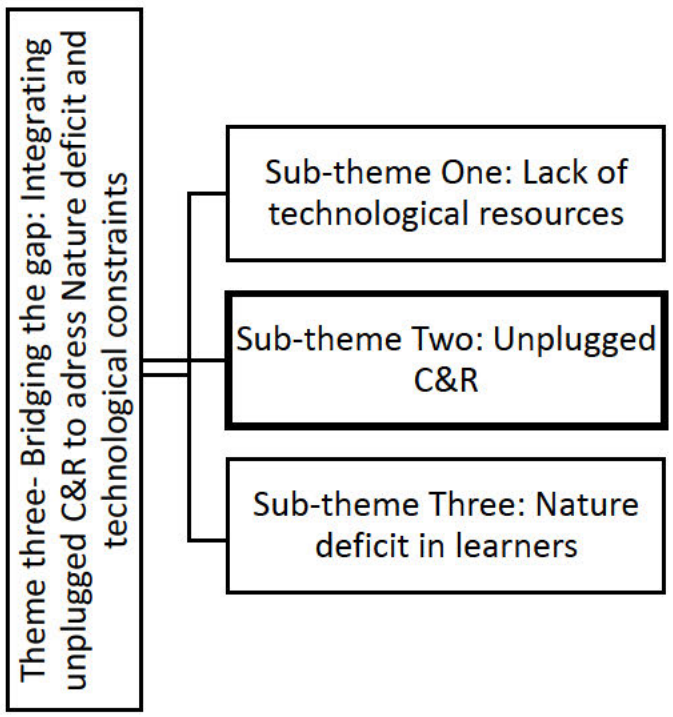
5.6 Theme Three: Bridging the Gap: Integrating Unplugged C&R to Address Nature Deficit and Technological Constraints

This theme emerged from the convergence of three subthemes: Lack of Technological Resources, Unplugged C&R and Nature Deficit in Learners. The theme highlights the need to address limitations in teaching C&R, particularly in resource-constrained environments, while

also fostering a connection with nature and developing essential skills in learners. This section addresses the research question: Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum? The researcher conducted questionnaires, semi-structured one-on-one interviews, and collage-making sessions to gather the data as presented below. The subthemes that emerged are displayed in the figure below and discussed thereafter:

Figure 5.6 (a)

Presentation of the Theme and Corresponding Subthemes



Note: Visual representation created by the author

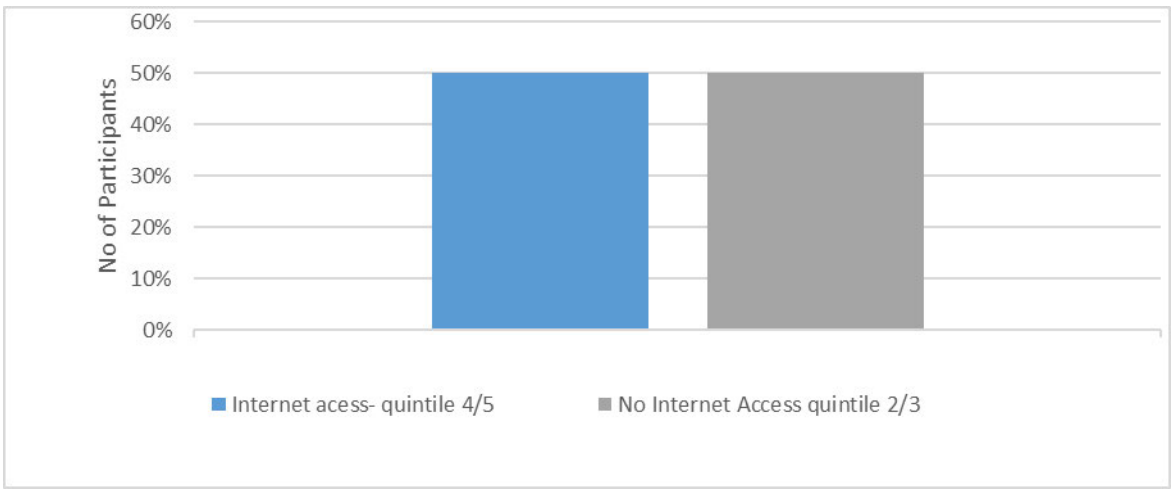
5.6.1 Subtheme One: Lack of Technological Resources

The lack of technological resources emerged as a subtheme. This subtheme was instrumental in answering Research Question Two: Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum? The data gathered from the questionnaires, one-on-one interviews, and the collages indicated that most participants teach in schools that lack computer labs or technological resources, including internet access, for the proper implementation of C&R at school. According to Jantjies (2019), the safety and security of computers and other technological equipment used for C&R also pose a challenge in South Africa. Janjies (2019) further asserts that this is due to the high crime rate in South Africa and the lack of funding to properly secure the equipment that will be used for implementing C&R in the classroom. Technological equipment and computer labs are needed to teach C&R. Below is information extracted from the questionnaires, presented in graphs, showing the number of participants with internet access and their availability to computer labs.

Figure 5.6.1(a)

Availability of Internet Access

The bar graph below reflects the number of participants who have access to the internet,



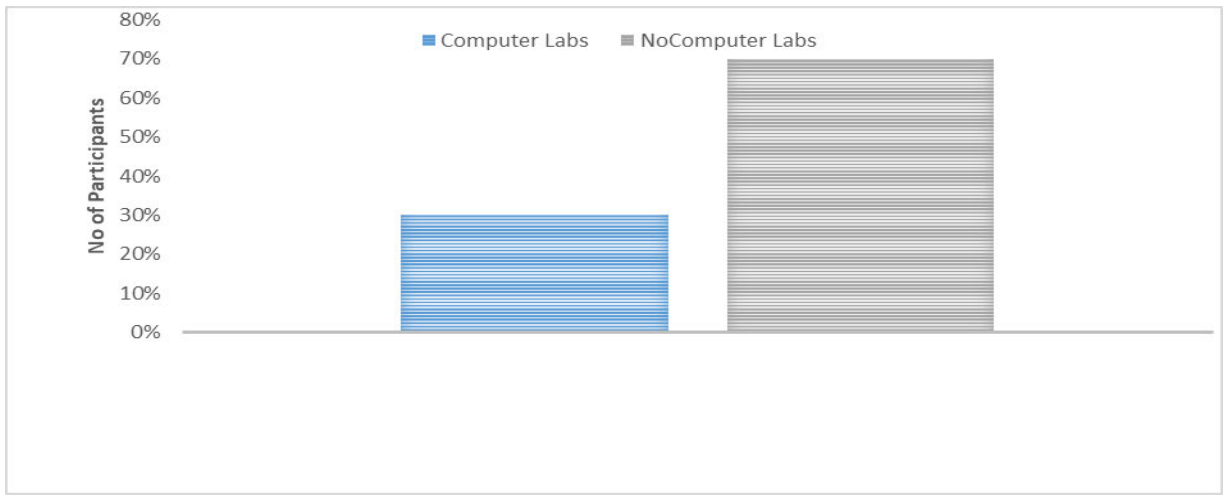
Note: Author-generated bar graph

Based on the information gathered from the questionnaires, it emerged that five participants out of the ten from quintiles 4 and 5 schools had access to the internet, and five participants out of the ten from quintiles 2 and 3 schools did not.

Figure 5.6.1(b)

Participants' Availability of Computer Labs

The bar graph below depicts the number of participants who have computer labs.



Note: Author-generated bar graph

The graph above shows that three of the ten participants from quintile 5 schools have computer labs, while the remaining seven participants from quintile 2, 3 and 4 schools do not. This aligns with Van Dyk and White (2019), who state that schools are ranked from quintile 5, which includes schools from affluent and advantaged communities to quintile 1, which includes schools from impoverished and disadvantaged communities.

5.6.1.1 Quintile-Based Disparities

The quintile of schools selected significantly influences how C&R are implemented, as low quintile schools are under-resourced and lack sufficient technological infrastructure. Consequently, this hinders the proper implementation of C&R by teachers at these schools (Jones, 2021).

The graph clearly shows that participants from higher quintile schools have access to computers and the internet required for teaching C&R. This resource gap impacts the efficacy and calibre of C&R implementation. On the other hand, lower quintile schools frequently face resource constraints that hinder the implementation of C&R curricula (Nguyen & Singh, 2022), as shown in the graph above, where seven out of ten schools lack computer labs or internet connectivity.

5.6.1.2 The Lack of Technological Equipment and Computer Labs

The lack of technological equipment and computer labs hinders the proper teaching of C&R. Participants PI-3, PI-10, and PI-7 highlighted the challenges faced by their schools, including a lack of computers and internet access, and safety and security concerns due to South Africa's high crime rate (Jantjies, 2019). PI-3 stated that their school lacks computers and internet access, which prevents them from practically demonstrating coding to learners and leads to boredom from repetitive theoretical explanations. Participants' Feedback as Reported during the one-on-one interviews is as follows:

PI-3 states that her school has no computers or internet access, which prevents them from demonstrating practical coding; as a result, they are just teaching theory, which makes learners bored. The school had a computer room that was sponsored; however, they lacked funding to

maintain it, so it remained outdated and was also subject to break-ins. PI – 3 had this to say:

> *Our school has no computer lab, nor do we have access to the internet for us to show learners physically how to code so we are basically just doing theory with the learners. Learners are getting bored, remember, because we are explaining the same thing over and over. We did have a computer room that was sponsored by Traffic Signals in 2012; however, the school does not have money to upgrade the computers, and now it cannot be used. We also had many break-ins at our school.*

Similarly, PI-10, a pilot school, reported a lack of resources to implement C&R effectively, resulting in learner disinterest.

> *We lack resources; we are literally a pilot school but have no resources to implement C&R properly. I download from sites off the internet, e.g. unplugged activities. Imagine we are a pilot school with no resources to implement: no internet, no computers.*

PI-7 asserted that their school lacks computers, internet connectivity, and basic resources, making it difficult to secure community funding because of its impoverished condition. Safety and security concerns were also raised due to the school's location in a high-theft area.

> *We are a poor school, so we don't have access to the internet. We don't have any computers, laptops, or tablets – nothing. Our community cannot afford to sponsor us with technology. We also have a lot of break-ins at our school, so having computers on the site is a risk, to be quite honest.*

PI-9 states that their school lacks a media room for laptop accessibility and Wi-Fi. The school is located near a high-risk area of violence, with frequent robberies and hijackings. Teachers will risk their lives to teach C&R because of the increased risk of theft. The school has been broken into multiple times, so the C&R subject increases the risk of theft and robbery. PI-9 had this to say:

> *At school, we do not have a media room that provides laptop accessibility to our learners. We do not have Wi-Fi that's available all the time. We are in an area where we are exposed to danger at any given time. Having many laptops here, it's not safe because we are on the edge of an area where violence is rife.*

PI – 2 states that teachers risk their lives teaching C&R due to the high crime rate. If criminals find out they are teaching C&R, they will be at greater risk of further break-ins.

> *We get robbed; we get hijacked. And across our school, there were shootings, people getting hijacked at our gate, in fact, teachers that come in and they're getting hijacked at the gate. The school has been broken into on various occasions. If the perpetrators of the theft and hijacking find out, we are doing C&R, we will be in more danger.*

South Africa needs to overcome certain challenges before successfully implementing C&R in schools, as Jantjies (2019) maintains. The lack of technological resources, coupled with the safety and security of these resources, is one of them. Janjies (2019) further asserts that this is due to the high crime rate in South Africa and the lack of funding to properly secure the equipment that will be used for implementing C&R in the classroom. Addressing these challenges is crucial to ensuring the successful integration of C&R into the C&R curriculum.

Figure 5.6.1.2(a)

Note. Image Extracted from Collage Two by PC-3.

The image presents a collage of three photographs depicting children in rural areas, without shoes and with inadequate learning facilities, emphasising the challenges schools face.

The collage suggests a significant disparity between the resources available to schools in rural areas and the expectations placed upon them. The lack of basic infrastructure, such as proper toilets and classroom furniture, is a significant challenge for these schools. Furthermore, expecting them to teach advanced subjects like C&R without adequate resources is unrealistic. The image above corroborates the study by Jones (2021), who claims that maintaining hardware is a challenge for public schools in South Africa, as 380 schools still lack water and 3 392 schools still use pit latrines. These schools lack funds for basic needs, as mentioned above, let alone funds to purchase and maintain hardware for C&R implementation.

5.6.2 Subtheme Two – Unplugged C&R

unplugged is an effective way to teach C&R, as nearly 16 000 schools in South Africa lack computer labs (BusinessTech. 2018). Unplugged Coding uses games or tasks that can be completed offline with tangible materials, such as paper, coloured pencils, markers, etc. It is a more

hands-on approach to teaching C&R, with a lot of active play. unplugged helps learners build computational thinking skills without computers or sophisticated technology (Aranda & Ferguson, 2018). Unplugged C&R promotes inclusive learning, as learners from all types of schools and backgrounds can participate.

Unplugged coding exercises have the potential to reach a larger audience because they utilise basic materials and activities (Curzon et al., 2019). Participants felt that C&R unplugged was more practical, as many of their schools lack the technical equipment and computer labs needed to implement the C&R curriculum successfully. Participants believed that C&R unplugged was an easier way to teach computational thinking and problem-solving skills than coding on a computer. Participant feedback as reported during the one-on-one interviews is as follows:

PI-3 had this to say:

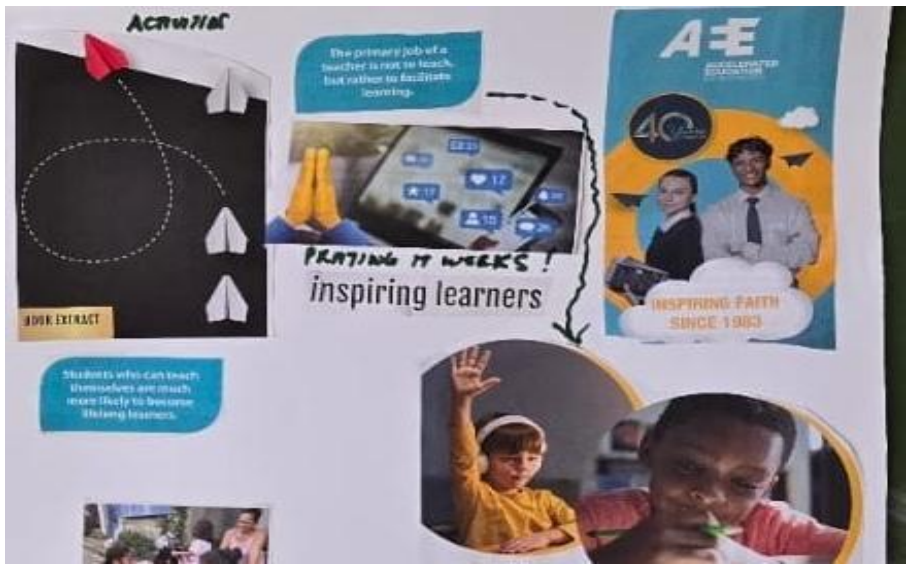
In my classroom, I'm only able to implement C&R Unplugged because my school does not have the resources to implement plugged C&R.

PI – 3 shares similar views, stating that C&R unplugged support inclusive learning. Learners can now develop problem-solving skills in C&R despite our school not having computers or laptops. PI-3 asserts that:

C&R Unplugged can be implemented across all learning communities, from the privileged to the underprivileged. It supports inclusivity.

Participants also included C&R unplugged C&R in their collages, which corroborates their belief that unplugged promotes inclusivity**.**

Figure 5.6.2. (a)



Note. Image Extracted from Collage One by PC – 1.

The collage, crafted by PC-1, effectively conveys the notion that C&R unplugged serves as a catalyst for inclusive education. By juxtaposing two learners – one using earphones to signify access to technological resources and the other actively engaged in learning with traditional tools such as a pen and paper – the image underscores the potential for educational inclusivity despite varying levels of access to technology. The image above demonstrates that learning can occur without technical equipment and that teachers can adapt teaching methods to accommodate learners with limited access to resources. This approach can help bridge the gap in educational opportunities and promote greater inclusivity in C&R education.

5.6.2.1 The Unplugged Blues: When C&R Gets Boring Without Tech

Participants further expressed that while they understand the value of teaching C&R unplugged, since their schools do not have computer labs, learners are becoming bored with only unplugged activities. At first, they were very excited to learn C&R; however, as time passed, they wanted to learn to code on a computer. Participants felt that the unplugged activities were becoming monotonous. Some participants reported that they did not have internet access to download unplugged activities, and that their school does not have unplugged activities as resources either. Participant Feedback as Reported during the one-on-one interviews is as follows:

As PI-5 noted, the lack of charts and facilities for plugged and unplugged activities, and a computer lab for teaching C&R, is causing learners to become bored with unplugged activities. Participant 5 had this to say:

> *Unplugged activities are beginning to bore my learners, as they want to use a computer and actually Code and not just do unplugged activities.*

While PI-9 contends that they received resources for Unplugged activities, including ATPs, CAPS documents, and charts, they have exhausted the use of the charts for Unplugged. Learners were bored with Unplugged and want to learn how to code on an actual computer. PI-9 had this to say:

> *We have limited resources, of which I have exhausted its use, and kids are getting bored asking me when we are going to go and code on an actual computer.*

PI-4 concurs by stating that she has limited unplugged activities because she does not have access to resources from the internet due to her lack of internet connectivity. PI-4 had this to say:

> *I've been doing unplugged for so long that kids just want to do Coding on the computer. I do not have much unplugged resources. It is difficult for me to download from the internet because I have to buy data, as I do not have fibre or unlimited data at home.*

PI – 10 stated that at first, learners were excited to do C&R unplugged, but after a while, they became bored and wanted to code and put into practice what they had learnt in the unplugged activity. PI – 10 had this to say:

> *Learners were excited at first about C&R, now they just get bored asking me when they will get a chance to actually code and use a computer, but we don't have computers, so how do we explain to the kids you can't actually do Coding cos there is no computers or internet.*

While C&R unplugged is a means to teach learners coding without technological resources and promotes inclusive learning, the study found that learners are bored with it because teachers lack sufficient, varied resources to keep learners intrigued and excited about learning the new subject. Learners also desire to learn C&R with technology; however, the majority of participants in this study teach in schools without computer labs or internet connectivity.

5.6.3 Subtheme Three: Nature Deficit in Learners

Nature deficit in learners is a subtheme that emerged and is also linked to Research Question Two: Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum? Participants expressed that children need to learn skills beyond plugged C&R, such as fine motor and muscle skills, as well as unplugged. This is so because learners are currently so attached to technology that they do not want to engage in physical activities. The concept of "nature deficit in childhood" (Louv, 2005) is central to this subtheme, emphasising the need for learners to engage in outdoor activities and develop a connection with nature.

5.6.3.1 The Impact of Excessive Screen Time on Learners

Participants reported that learners often struggle with communication and teamwork due to excessive screen time, which limits their ability to understand human values and gestures. in school encourage screen time, making it difficult for children and even adults to put their devices away when others are around. Participants further expressed that, instead of C&R with technology, unplugged will benefit learners more, since plugged-in immerses them in technology they are already addicted to. Participant Feedback as Reported during the one-on-one interviews is as follows:

PI – 4 had this to say:

> *I prefer learners to engage in unplugged C&R because, apart from the lack of resources to implement it, it helps our learners to be more hands-on, involved, and does not add to their overstimulation of technology, such as phones and iPads, etc., that they have access to at home.*

As further expressed by PI-5, learners are increasingly focusing on technology at school and cannot concentrate on simple conversations because they are already so mentally stimulated by technology. PI-5 further iterates the concerns raised by others, stating that learners cannot focus on a normal conversation because they are so fixated on their devices. Participant 5 went on to explain that C&R are creating a future workforce that cannot separate from technology nor have a decent conversation with you. PI-5 had this to say:

> *They are stuck on the phone, and if you are having a conversation with a learner, their head is on the phone, and they won't give you the attention or respect when you are speaking to them. That's not our culture; that's not what we are trying to teach our children.*

PI-1 states that learners at school often struggle with communication and teamwork due to excessive screen time, which limits their ability to understand human values and gestures. are taught at school, and these subjects encourage screen time, making it difficult for children to put their devices away when in front of others. It is crucial to show respect and face-to-face interaction to help children develop the skills needed for a healthy, respectful technological world. PI-1 had this to say:

> *They won't be having the ability to be artistic, use your hands, freehand drawing, using your fingers to hold a pen. They won't even be able to hold a pair of scissors to cut properly because you're using cut-and-paste – what's the use of a pair of scissors? Learners are so fixated on technological gadgets.*

The views expressed by participants regarding nature deficit in learners are further encapsulated in the collage one, where the image of a girl being covered in mud is extracted and displayed below.

Figure 5.6.3.1 (a)

Note. Extract from Collage One by PC – 2.

The image presented by PC-2 serves as a poignant illustration of the limitations imposed on children's outdoor play experiences. The depiction of a child covered in mud and appearing distressed highlights the consequences of restricted interaction with the natural environment. This visual representation underscores the notion that children are increasingly disconnected from their surroundings, emphasising the need for greater exposure to nature in their daily lives."

Figure 5.6.3.1 (b)

Note. Image Extracted from Collage One by PC-1

The image illustrates a crucial concern regarding the impact of excessive technology use on children's development. The juxtaposition of two cartoon images – one depicting a woman practising yoga and the other showing a woman appreciating art – serves as a visual representation of the need for children to cultivate their creative and natural inclinations. By emphasising the importance of balancing technological advancements with exposure to art and nature, the image underscores the need for a more holistic approach to childhood development. This perspective is particularly relevant in the context of the growing prevalence of C&R in modern education, which, while valuable, should not come at the expense of other essential aspects of a child's growth.

5.7 Conclusion

This chapter presented findings from questionnaires, interviews, and collages, which collectively provided insight into teachers' experiences implementing the C&R curriculum. The data revealed a spectrum of emotions, ranging from intimidation and frustration among teachers in lower quintile schools to perseverance and hope expressed by those in higher quintile schools. The findings also highlighted key stumbling blocks to transformation, including ineffective training, overcrowded classrooms, and limited inclusivity in the C&R curriculum. Furthermore, the chapter demonstrated the significance of integrating unplugged approaches as a practical response to technological and resource constraints, while also addressing the growing nature deficit in learners. Taken together, these findings underscore the contextual challenges and opportunities that shape the implementation of C&R in South African schools, providing a foundation for the discussions that follow in the next chapter.

CHAPTER 5 – PART B: POST-INTERVENTION WORKSHOP ANALYSIS AND CURRICULUM ADAPTATION

5.8 Introduction

The previous chapter presented the findings, analysis, and discussions of the first two research questions. This chapter presents, analyses, interprets, and discusses the findings according to the third research question: *How can the C&R curriculum be adapted to effectively address the specific needs and contextual realities of the school?* It examines whether participants' perspectives evolved and how they applied the knowledge and skills gained to adapt the C&R curriculum to the unique contexts and needs of their schools, thereby addressing the third research question. To answer this question, data were generated across five workshops (phase 4), supplemented by five focus group interviews (phase 5) conducted immediately after each workshop and reflective questionnaires administered three months' post-workshop. The reflective questionnaires were deliberately administered after a single school term, comprising three consecutive months, to allow participants time to practice the activities presented during the workshops. The intention was to determine whether participants' views changed after attending the unplugged workshops and whether they were able to utilise the skills learnt to effectively address the specific needs and contextual realities of the school. The focus group interviews and the reflective questionnaires were based on the workshops conducted.

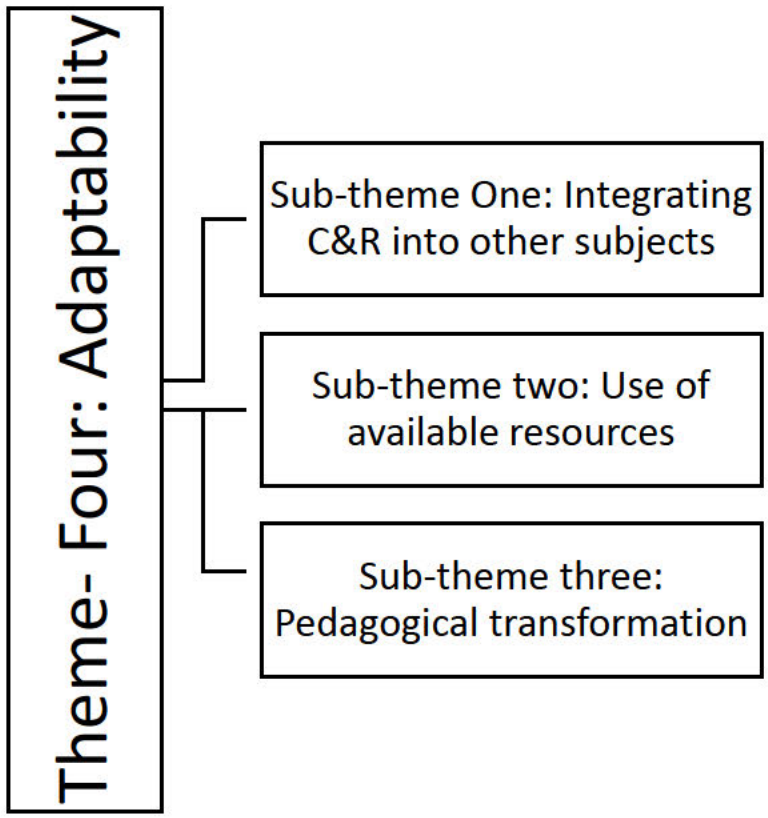
5.9 Theme One – Adaptability

The theme that emerged from the focus group interviews and reflective questionnaires after conducting the workshops was adaptability. Participants expressed that the nature of C&R is one of constant change; hence, the C&R curriculum must be adaptable to these changes. Participants further described in the focus group interviews that adapting the C&R curriculum to meet the school's needs is essential for efficient teaching and learning and for implementing C&R techniques. Adaptability in the context of C&R refers to the capacity to cope with new, unanticipated, or unpredictable situations, such as innovative programming languages, evolving technologies, or sudden system failures (Hatcher, 2020).

To achieve adaptability, the CAPS Document advises teachers to cultivate a learning atmosphere that fosters learners' interest in digital technology, enhances their creativity and responsibility, and boosts their confidence in utilising technology through C&R (DOE, 2023). The subthemes that emerged from the theme above were: the integration of C&R into other subjects, the use of available resources, and pedagogical transformation. Below is a diagram of the themes and their corresponding subthemes.

Figure 5.9 (a)

Presentation of the Theme and Corresponding Subthemes.



Note. Created by the author.

5.9.1 Subtheme one: Integration of C&R into Other Subjects

C&R is an interdisciplinary field that integrates concepts from Mathematics, Science, Technology, Engineering, and Language Arts (Tshabalala & Mthembu, 2022). Despite its multidisciplinary nature, C&R is currently a standalone subject (DBE, 2024). Despite it being a standalone subject, the time allocated to teach C&R is taken from the Life Skills allocation in the Foundation Phase as per the CAPS Document (DBE, 2024). Figure 2 shows the CAPS layout of subject offerings at Grade R-3 prior to integrating C&R into the CAPS Document.

Figure 5.9.1(a)

CAPS Document Depicting the Time Allocation of the Subjects.

SUBJECT	GRADE R (HOURS)	GRADES 1-2 (HOURS)	GRADE 3 (HOURS)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Life Skills	**6**	**6**	**7**
• Beginning Knowledge	(1)	(1)	(2)
• Creative Arts	(2)	(2)	(2)
• Physical Education	(2)	(2)	(2)
• Personal and Social Well-being	(1)	(1)	(1)
TOTAL	**23**	**23**	**25**

Note. Adapted from *Curriculum and Assessment Policy Statement (CAPS): Foundation Phase Grades R-3*, by the DBE, 2012, p 7)

The figure above reflects Life Skills from Grade R to Grade 2 with a time allocation of six hours and Grade 3 with seven hours. This was previous to the integration of C&R into the CAPS Document as displayed below:

Figure 5.9.1 (b)

Extract from the CAPS Document Including C&R

Subject	Grade R (Hours)	Grades 1-2 (Hours)	Grade 3 (Hours)
Home Language	10	7/8	7/8
First Additional Language		2/3	3/4
Mathematics	7	7	7
Life Skills	**5**	**5**	**5**
• Beginning Knowledge	(1)	(1)	(1,5)
• Creative Arts	(1,5)	(1,5)	(1,5)
• Physical Education	(1,5)	(1,5)	(1)
• Personal and Social Well-being	(1)	(1)	(1)
Coding and Robotics	(1)	(1)	(2)
Total	**23**	**23**	**25**

Note. Adapted from *Curriculum and Assessment Policy Statement (CAPS): Foundation Phase Grades R-3*, by the DBE, 2024.

Figure 5.9.1 (b) depicts the latest CAPS Document reflecting the time allocated for C&R, which is one hour from Grade R to 2 and two hours for Grade 3. Life Skills allocation for the week was 6 hours from Grade R to Grade 2 and seven hours for Grade 3, as depicted in Figure 2. Figure 3 illustrates that the time allocated to Life Skills has decreased by one hour for Grade R to 2 and by two hours for Grade 3, and has been replaced by C&R. Hence, the Life Skills allocation is now five hours a week from Grade R to 2 and six hours for Grade 3 (DBE, 2024). The above figure reflects that the time allocated for teaching C&R subject has been taken out of the Life – Skills time allocation.

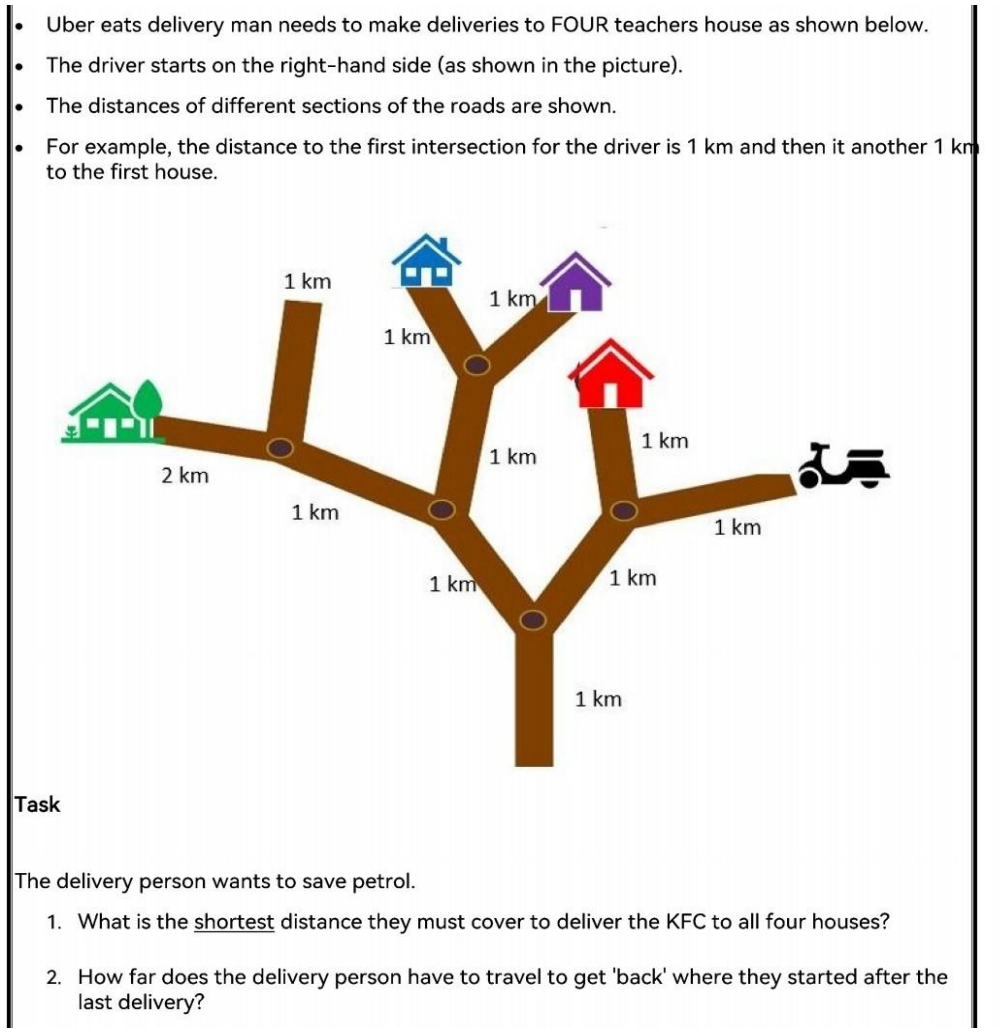
Participants expressed that they can adapt the C&R curriculum to meet the needs of their school by integrating it into all three subjects: Mathematics, English and Life Skills thereby increasing its time allocation resulting in more effective teaching of the aims and objectives of the C&R curriculum. Participants expressed their dissatisfaction with the current time allocation of the C&R subject in the Junior phase being one hour for Grade R to Grade 2 and two hours for Grade 3 as displayed above. These feelings arouse after participants engaged in Workshop One that required them to perform mathematical calculations and read the signs as they navigated through solving the problem that emerged as part of the C&R task. The activity highlighted the interdisciplinary nature of the C&R curriculum and is examined further below.

Workshop One-Activity Description: Introduction to C&R Unplugged – Find the Shortest route

Workshop One introduced participants to the basics of C&R. The workshop was conducted in an unplugged format, focusing on problem-solving, critical thinking, reading, and outdoor play. Below is the image of the activity which was used at the workshop. The participants looked at the question and came up with creative ways to teach the subject by using a mat and taking the activity outdoors. They placed pictures of houses on the mat and acted out the activity trying to find the shortest route.

Figure 5.9.1(c)

Activity Done in Workshop One – Shortest Route for Uber Delivery Person



Note. Adapted from Tangible Africa: *Unplugged activities, by Leva Foundation, n.d.*(https://tangible.levafoundation.org/)

The activity above examined the interdisciplinary nature of C&R as expressed by the participants. Below is an actual picture taken from Workshop One that was conducted during the research.

Figure 5.9.1 (d)

Note. Photograph of Workshop One – Shortest Route for Uber Delivery Person

This picture depicts the participants actively involved in an activity that requires them to be engaged in counting (Mathematics), reading (English) and Life Skills (Outdoor play) in order to complete the C&R task. The activity was to find the easiest route for the delivery guy to deliver your food. The activity showed various routes (drawn on the purple mat above), requiring participants to read (English), calculate (Mathematics) the kilometres for each direction, and physically engage in movement (Life Skills) to navigate each route and find the quickest one. Following the activity conducted during Workshop One, a focus group discussion was held for participants to reflect on their participation and the actual activity content. A predominant subtheme that emerged among participants was that C&R should be integrated into other subjects, thereby increasing the time allocated to C&R. Participants further expressed that the time to accomplish the aims, skills, and content as set out in the CAPS Document 2024 is insufficient.

Participants advocated for a more interdisciplinary approach, suggesting that C&R be integrated into Mathematics, English, and Life Skills, thereby allocating more time to teach the subject and fulfil its aims and objectives. Participants justified the inherent connections between C&R and other subjects during focus group interviews. They noted that C&R involve problem-solving, a fundamental aspect of Mathematics, and requires learners to read instructions, thereby incorporating English language skills and Life Skills in solving problems. As stated by Hsu et al. (2022), integrating C&R into other subjects can improve learners' problem-solving abilities and promote a more comprehensive comprehension of the subject. For example, Hsu et al. (2022) found that an educational robot-based method that combined C&R with language learning increased learners' problem-solving skills while reducing their anxiety during language learning.

Furthermore, participants recognised that Life Skills, particularly in the Foundation Phase, are essential for learners' overall development and should not be compromised the Life Skills subject focuses on learning fundamental skills such as critical thinking, problem-solving, and communication (DBE, 2020). The Life Skills curriculum was intended to provide learners with the skills and information needed to manage the obstacles of everyday. Participants expressed that reducing Life Skills to only the C&R curriculum allocation (DBE, 2024) to accommodate C&R deprives learners of valuable skills integral to their overall functioning.

Participants expressed that they can adapt the C&R to suit the needs of their schools without compromising the integrity of the Life Skills subject, since these skills are integral for learners. Hence, they believe that C&R should also be integrated into other subjects, such as Mathematics, English, and Life Skills. This will increase the time allocation for the C&R subject, improving the quality of teaching and achieving the subject's aims and objectives. Participant Feedback as Reported during Focus Group Interview One is as follows:

As expressed by PFG-1

> *Life Skills are an important subject, especially in the foundation phase. Children require all the time they need to build, play, and exercise. Why can't the DBE take out half an hour from Mathematics, English, and Life Skills instead of one hour from Life Skills only? If we take time from all three subjects, we will have more time to accomplish the aims set out in the CAPS Document.*

PFG-5 emphasised that the one hour allocated to teach C&R was insufficient to achieve its objectives. PFG-5 further explained that the time can be extracted from other subjects as well not just Life Skills. Participant noted:

> *The C&R subject requires us to teach specific aims and objectives. The one hour a week is not sufficient. We must adapt the subject aims and objectives into English, Mathematics, and Life Skills, then we will see to achieve the outcomes.*

PFG-10 stated that C&R is also similar to English and Mathematics and should be included as part of those subjects.

C&R is very similar to English and Mathematics as well. C&R should be integrated into English and Mathematics as well as Life Skills. I feel we should not take time from Life Skills only to do C&R because kids need life skills to transition into formal written work. Therefore, it should be spread across the three subjects in the Foundation Phase.

The participants agreed that the C&R curriculum could be effectively tailored to align with the school's requirements by integrating its goals and objectives across the three subjects. Diverting instructional time from Life Skills to accommodate C&R could compromise learners' comprehensive development. The primary insights gleaned from the reflective questionnaires administered three months after the workshop underscored participants' persistent emphasis on the importance of seamlessly integrating C&R into the existing curricular framework. Participant Feedback as Reported during the reflective questionnaires are as follows:

PRQ-1's assertion that integrating C&R into Mathematics and English lessons has been a "game-changer" for their learners underscores the transformative potential of this approach. The participant's observation of increased learner interest and enjoyment suggests that incorporating C&R can enhance learners' engagement and motivation, potentially leading to improved academic outcomes.
PRQ-1 noted:

I have integrated C&R into my Mathematics and English lessons, and it has been a game-changer for my learners. Learners are more interested and are having fun doing Mathematics and Coding.

PRQ-10's ability to meet some of the subject's aims and objectives more effectively by integrating C&R into Mathematics and English highlights the flexibility and adaptability that this approach affords. By transcending traditional time constraints, the participant is able to adopt a more holistic and interdisciplinary approach to teaching, potentially leading to a more nuanced and comprehensive understanding of the subject matter. PRQ – 10 noted:

I am able to meet some aims and objectives of the subject because I am not confined to just one hour now. I am integrating C&R into Mathematics and English as well.

PRQ-5 noted that incorporating C&R into English lessons improved comprehension, critical thinking, and writing confidence among learners, demonstrating the value of creative expression in education. This finding underscores the value of creative expression in education and highlights the potential for C&R to be used as a tool for enhancing literacy and cognitive development. PRQ-5 noted:

I incorporated robotics into my English lessons by having learners design and build robots using paper plates and other recyclable materials that could retell a story. It was amazing to see learners' comprehension and critical thinking skills improve.

Participants emphasised the importance of adapting C&R into various subjects beyond Life Skills. is an interdisciplinary field (Güleryüz, 2023) hence it should be integrated into the C&R curriculum in a way that respects its connections to other subjects. Participants expressed that time should be allocated from the three subjects: English, Mathematics, and Life Skills and not just Life Skills in the Foundation Phase. Moreover, preserving the integrity of the Life Skills subject is crucial for the holistic development of children. By doing so, the C&R curriculum becomes more flexible and adaptable, enabling it to better meet the diverse needs of the school. This integration can potentially enhance the overall effectiveness of the C&R curriculum.

5.9.2 Sub-theme Two: Use Available Resources

Workshops two and three introduced participants to unplugged coding activities, designed to develop problem-solving skills and critical thinking using limited resources that they have and integrating it into the lesson. The workshops were conducted in groups, enabling interactive, collaborative learning.

Figure 5.9.2(a)

Note. Photograph of Workshop Three – Leveraging Limited Resources to Design a Robot.

5.9.2.1 Activity Description

Above is a photo taken during Workshop three, participants had to utilise available resources to design a robot. The participants engaged in creative activities that exemplified resourcefulness and adaptability. Using readily available school resources, they designed and constructed cardboard robots, showcasing their innovative problem-solving skills. This activity served as a practical demonstration of how limited resources can be leveraged to achieve successful outcomes in C&R education. By repurposing available materials, participants illustrated the potential for

adapting resources to meet the unique needs and constraints of their school. This exercise also highlighted the importance of flexibility and creativity in teaching C&R, particularly in resource-constrained environments. By embracing resourcefulness and adaptability, teachers can provide learners with engaging and effective learning experiences despite limitations. Participant Feedback as Reported during Focus Group Interviews Two and Three is as follows:

PFG-1 This participant emphasised the resourcefulness developed during the workshop, highlighting the ability to utilise limited resources effectively in teaching C&R. PFG-1 had this to say:

> *Despite the limited resources, we can use the tools we developed in this workshop to teach C&R in a positive way.*

PFG-3 concurred with PFG-1, expressing enthusiasm for incorporating innovative problem-solving skills acquired during the workshop into their classroom teaching. PFG-3 intends to challenge their learners to build a robot from recycled parts, promoting critical thinking, teamwork, and creativity.

> *I'm looking forward to incorporating the innovative problem-solving skills I acquired in the workshop into my classroom. Using limited resources, I can now teach my kids how to think outside the box and create new solutions. For example, I intend to challenge my learners to build a robot out of recycled parts, which will encourage critical thinking, teamwork, and creativity.*

PFG-6 expressed hope that C&R could become interactive and accessible to their learners. PFG-6 is now inspired to integrate these subjects into their existing curriculum using everyday objects to demonstrate complex concepts, making learning more engaging and accessible.

> *I'm now inspired to integrate C&R into my existing curriculum, using everyday objects to demonstrate complex concepts. I believe I can make learning more engaging, interactive, and accessible to all my learners.*

PFG-8 was amazed by how the workshop's unplugged coding activities brought C&R to life without computers or robots. PFG-8 realised that with minimal resources and a bit of creativity, you could teach the fundamentals of C&R.

> *I was amazed by how the workshop's unplugged coding activities brought C&R to life, even without computers or robots. I realised that with a little creativity, I can teach my learners the fundamentals of C&R using minimal resources.*

The feedback from participants in the focus group interviews highlighted their positive experiences and insights gained during workshops two and three on C&R. The participants expressed their thoughts on how the workshops have influenced their approach to teaching and their plans for utilising limited resources to teach C&R unplugged. Participant Feedback as Reported during the reflective questionnaire is as follows:

Three months' post workshop, participants reflected on how they had applied the skills they acquired in their classrooms. The participants noted that their learners benefited from the hands-on activities, which improved their problem-solving skills. This indicates that the workshop offered practical, cost-effective solutions for teaching complex subjects. As noted by PRQ-3:

> *The workshop was an eye-opener. I learnt how to teach C&R at no cost. My learners appreciate the hands-on activities, and I've noticed a significant improvement in their problem-solving abilities.*

PRQ-1 highlights the success in engaging their learners in C&R using readily available resources. The fact that the learners enjoyed building robots with materials found around the school demonstrates the workshop's emphasis on resourcefulness and creativity. As a result, the learners have become more interested and confident in these subjects.

> *My children really enjoyed building robots with resources they found lying around the school. They are now more interested and confident in C&R.*

PRQ-9 noted that they are able to "think outside the box," and adapt the workshop's principles to their own teaching environment, using available resources to engage their learners. The learners' positive response suggests that the workshop's methods are effective and enjoyable.

> *I was apprehensive at first, but the workshop taught me how to think outside the box. Now I'm teaching C&R with things I find around my school, and my learners are loving it.*

Overall, the feedback received from the reflective questionnaires suggests that the workshop was successful in equipping participants with the skills and confidence to teach C&R effectively, even with limited resources. The feedback highlights the workshop's impact on both the participants and their learners, demonstrating its potential to improve educational outcomes through leveraging limited resources.

5.9.2.2 Creative Ways of Leveraging Limited Resources

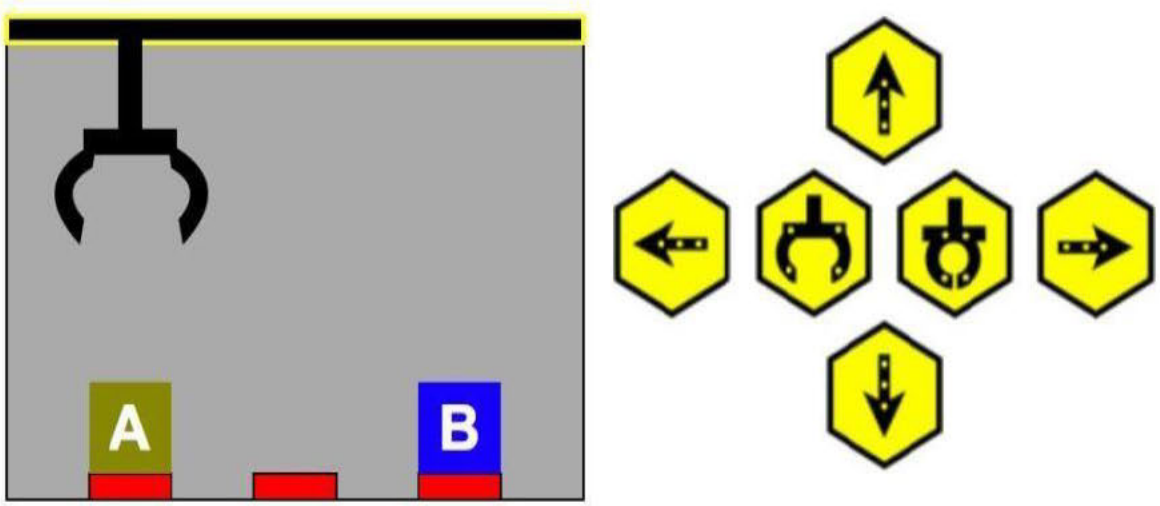
During workshop four, the idea of bringing C&R to life using resources found around the school was further explored. Below is an image of the activity conducted during the workshop. The activity depicts an unplugged C&R activity related to operating a crane. The task was to determine the correct sequence of instructions to swap the positions of the two crates labelled A and B. Below is the actual activity presented at the workshop, followed by a picture of the participants leveraging available resources to contextualise it.

5.9.2.2 (a) Activity Conducted during Workshop Four – Caryn the Crane Driver

Caryn operates a crane that responds to six different input commands:

Left	Right	Up	Down	Grab	Release
Move crane one to left	Move crane one to right	Move Crane Up	Move Crane Down	Grab the box below	Release the box that was grabbed

Which is the correct set of instructions to swap the position of the two crates (A and B)?



A. (Down, Grab, Up, Right, Down, Release, Up)

B. (Down, Grab, Up, Right, Down, Release, Up)
(Right, Down, Grab, Up, Left, Left, Down, Release, Up)(Right, Down, Grab, Up, Right, Down, Release)

C. (Down, Grab, Up, Right, Right, Down, Release, Up)(Down, Grab, Left, Down, Release, Up)
(Down, Grab, Up, Right, Down, Release, Up)

D. None of the above is correct

Note. Adapted from *Tangible Africa: Unplugged activities*, by Leva Foundation, n.d.(https://tangible.levafoundation.org/)

5.9.2.2 (b) Enactment of Caryn the Crane Driver

Note. Image taken by the Author

Above is an image of the activity in workshop four, in which participants had to leverage available resources to simulate the activity in a real-life context. Participants were challenged to look around and come up with ideas of how they can re-enact the activity displayed above of the movement of the crane using resources they found lying around. Participants used bottles and plain paper which they marked with the alphabet A and B to depict the two different crates as per the activity above. The participants then used their hands as the cranes and tried to move the crates as per the order above. This activity emphasised that participants could leverage limited resources to teach the C&R in a fun and hands-on way. Participants had the following to say after workshop four and during the focus group interviews. Participant Feedback as Reported during Focus Group Interview Four is as follows:

The participant's reflection on the workshop activity highlights the importance of creativity in educational settings, particularly when resources are limited. This insight underscores the value of innovative teaching methods that can be adapted to various educational environments. PFG-3 had this to say:

> *The activity was incredibly insightful. It made me realise how much creativity is required when resources are limited*.

PFG-6 initial scepticism about using everyday objects to teach complex concepts, followed by their surprising effectiveness, illustrates the

potential of non-traditional teaching tools. It suggests that teachers can leverage readily available materials to enhance learning experiences.PFG-6 had this to say:

I was sceptical at first but using everyday objects to teach complex concepts was surprisingly effective.

PFG-4 reflection on the challenges faced and the subsequent adaptation of the activity to their classroom setting demonstrates the workshop's impact on their pedagogical approach. It highlights the importance of flexibility and creativity in teaching practices. PFG-4 had this to say:

It was challenging, but it made me think outside the box and consider how to adapt this in my classroom.

Participant Feedback as Reported During the reflective questionnaires are as follows:

PRQ-2 was able to successfully implement the crane activity three months' post-workshop, utilising similar limited resources. The positive response from learners and the enhancement of their understanding of C&R underscore the workshop's long-term effectiveness.

Three months after the workshop, I was able to successfully implement the crane activity in my classroom using similar limited resources. The learners enjoyed it, and it helped them understand the basics of C&R.

PRQ-10 initially faced challenges due to a lack of support but eventually was successful in implanting the activity.

Initially, I faced challenges in replicating the activity due to lack of support from some colleagues. However, once I got the hang of it, the learners responded positively, and it became a regular activity in our coding club.

PRQ-7 notes that the workshop provided the confidence to improvise and create a similar activity using local materials, which was well-received by their learners. This outcome highlights the workshop's role in empowering teachers to innovate and adapt their teaching practices.

The workshop gave me the confidence to improvise. I used the principles learnt to create a similar activity using local materials, which was a hit with my learners.

The participant feedback underscores the workshop's effectiveness in enhancing teaching practices, promoting creativity, and improving learner outcomes. Despite having limited resources, participants were able to teach C&R effectively in their classrooms by utilising the tools of creativity and adaptability that they gained in the workshop. The importance of critical thinking, innovative problem-solving, and teamwork in attaining favourable results was also emphasised in the participants' reflections. These conclusions are supported by research, which

indicates that situations with limited resources might encourage creativity and flexibility (Blikstein, 2020; Sengupta et al., 2020). Furthermore, the experiences of the participants highlight the value of adaptability and creativity in teaching Robotics and Coding.

5.9.3 Subtheme Three: Pedagogical Transformation

The five-day workshops significantly enhanced participants' capacity to integrate C&R into their curriculum, fostering innovative approaches that addressed the specific needs of their schools. A notable subtheme that emerged from this integration was the mitigation of nature deficit among learners through pedagogical transformation. By incorporating outdoor C&R activities, participants provided learners with experiential opportunities that bridged the divide between technology and the natural environment. This approach not only facilitated a more holistic understanding of C&R but also contributed to addressing the nature deficit, identified as a subtheme above.

5.9.3.1 Activity Description:

One of the activities conducted during Workshop Five exemplified this innovative approach. The activity, titled "The short and the tall of it," involved a family of five children – Amy, Bula, Carla, Denga, and Earl – each with distinct heights, standing in a line. This activity was designed to promote creative thinking in teaching C&R through unplugged outdoor activities. By relocating these activities from the traditional classroom to outdoor environments, participants were able to alleviate concerns about nature deficit among learners. As participants re-enacted this activity under the researcher's guidance, they developed a deeper appreciation for the natural world while acquiring essential C&R skills.

Figure 5.9.3.1(a)
Activity done in Workshop Five – The Short and the Tall of it.

- A family of 5 children, namely Amy, Bula, Carla, Denga and Earl, all are different heights.
- They all have different heights.
- They stand in a line as shown below:

- Then they each count how many children are taller than they are, both in front of them and behind them.
- They give you the results on a slip of paper as follows:

Name	*Taller children in front*	*Taller children behind*
Amy	1	2

Bula	3	1
Carla	1	0
Denga	0	0
Earl	2	0

In what order are they currently standing (from left to right)?

A. Denga, Carla, Amy, Bula, Earl

B. Amy, Carla, Denga, Earl, Bula

C. Denga, Amy, Carla, Bula, Earl

D. Denga, Amy, Earl, Bula, Carla

E. None of the above are correct

Note. Adapted from *Tangible Africa: Unplugged Activities*, by Leva Foundation, n.d.(https://tangible.levafoundation.org/)

Figure 5.9.3.1(b)
Workshop Five: Visual Enactment of Activity -The Short and the Tall of it.

Note. Workshop Five: Visual Enactment of Activity -The Short and the Tall of it.

The image above illustrates participants mimicking the activity presented at Workshop Five. This activity aimed to exemplify the principles of "contextual learning," in which learning is made more effective by grounding it in a real-world setting. By conducting the coding activity

outdoors, the participants experienced a fresh, captivating learning environment, which, in turn, augmented their motivation and active participation. This helps reduce nature deficit among learners by ensuring they are outside in nature and engaging in C&R unplugged activities, as shown in the portrait above. Each participant was arranged according to the order as depicted in the activity above. This brought the activity to life, making it easier for learners to understand and visualise it.

Participant Feedback as Reported during Focus Group Interview Five is as follows:

PFG-5 appreciated the ease of adapting coding activities to an outdoor setting and enjoyed the experience, intending to replicate it with their learners. The participant found the outdoor coding activity engaging and effective, planning to implement it in their teaching.PFG-5 had this to say:

> *I was astonished by the ease with which I could adapt the coding activities to an outdoor setting. We were thoroughly engaged and derived considerable enjoyment from the experience. I intend to replicate this approach with my own learners.*

PFG-3 was amazed at how easily the coding activities were adapted to an outdoor setting and enjoyed the experience, highlighting a pedagogical transformation. The participant experienced a significant shift in their teaching approach following the outdoor coding activity. PFG-3 had this to say:

> *I was amazed at how easily we adapted the coding activities to an outdoor setting. We were completely engaged and enjoyed the experience. I will try this with my learners.*

PFG-2 emphasised the idea of 'pedagogical transformation,' in which teachers' beliefs and practices are altered through exposure to new ideas and experiences. The participant's realisation that C&R can be taught outdoors represents a significant change in their pedagogical approach. PFG-2 had this to say:

> *The outdoor activity was a game-changer for me. I realised that C&R does not have to be confined to the classroom.*

PFG-8 expressed enthusiasm for continuing the outdoor coding approach in their teaching practice. The workshop had a lasting positive impact on the participants' teaching methods. PFG-8 had this to say:

> *The workshop demonstrated that C&R can be taught in a way that is both fun and connected to nature by taking the activities outside. I'm looking forward to continuing this approach in my teaching practice.*

Participant Feedback, as reported during the reflective questionnaires, is as follows:

Participants reflected three months after the workshop in the reflective questionnaires as follows: The PRQ-1 stated:

> *I was initially hesitant to take coding outdoors, but after the workshop, I felt confident to try it. The learners responded really well to the activity, and it was great to see them enjoying the outdoors while learning*.

The participant's increased confidence in teaching coding outdoors represents a significant improvement in their self-efficacy. PRQ-5 noted:

> *I tried the outdoor activity at my school, and the learners loved it. They were able to see the connection between coding and the natural world.*

The participant's observation that learners were able to see the connection between coding and the natural world represents a significant achievement in promoting authentic learning.

PRQ-9 noted the following:

> *I was surprised at how easily the learners adapted to the outdoor C&R activities and how they loved it.*

PRQ-7 noted:

> *I integrated outdoor C&R Unplugged activities and loved watching my learners develop a greater appreciation for the natural world.*

By incorporating outdoor C&R activities, participants provided learners with experiential opportunities that bridged the divide between technology and the natural environment. This approach not only facilitated a more holistic understanding of C&R but also contributed to addressing the nature deficit identified above. The workshop's effectiveness was evident in the participants' increased confidence in teaching coding outdoors, representing a significant improvement in their self-efficacy.

5.10 Conclusion

In this chapter, the findings from the analysis of qualitative data generated from ten participants were presented. The researcher was guided by the research questions when developing and delivering the data, the literature review, and the theoretical framework. The implementation of C&R in primary schools in South Africa has yielded significant insights into the challenges and opportunities it presents. A notable theme that emerged from the study is teachers' emotional responses, which ranged from intimidation and frustration to perseverance and hope. This disparity

in emotional responses was largely influenced by the schools' socioeconomic context: teachers from lower quintile schools expressed more negative emotions due to inadequate resources and support, whereas teachers from higher quintile schools expressed hope and perseverance.

The study further highlights several systemic challenges that hinder the effective implementation of C&R in primary schools. These challenges include inadequate technological infrastructure, insufficient internet access, and a lack of inclusivity and accessibility for learners with disabilities or from disadvantaged backgrounds. To address these challenges, the study suggests that schools adopt a more holistic and adaptable approach to teaching C&R. This can be achieved by integrating C&R into other subjects, leveraging available resources, and incorporating outdoor learning activities that promote experiential learning and bridge the divide between technology and the natural environment. By adopting such an approach, schools can provide learners with a comprehensive and inclusive education that prepares them for success in the 21st century. The next chapter presents a detailed discussion of the findings, drawing on current scholarship and the theories discussed.

CHAPTER SIX DISCUSSIONS OF FINDINGS
'Cracking the Code'

6.1 Introduction

Chapter Five provided a detailed presentation of the data collected in the study. The findings from this study answered the research questions comprehensively, offering a deeper understanding of how the C&R curriculum can be improved. Themes and corresponding subthemes emerged from the collected data. The framework guiding this study was based on two theories: first, Rogers' (2003) IDT, and second, Fullan's (1993) Theory of Deep Change. The two theories were combined to form the conceptual framework, which provided a lens through which the researcher explored how the C&R policy was communicated and implemented by teachers. The IDT, as premised by Rogers (2003) is that teachers' acceptance and knowledge of a curriculum determines the level of effectiveness of its diffusion, while the Theory of Deep Change, according to Fullan (2004) states that for deep change to occur (the deep change being the diffusion of the C&R curriculum) there must be a deep understanding and deep learning of the phenomena under study. This study considered the above theories in analysing the data and discussing the findings.

The conceptual framework led to the fifth stage, an extension of both IDT and the Theory of Deep Change. The fifth stage was the new knowledge that this study contributed. This stage is the adaptation stage. The adaptation stage was only possible by combining the two theories mentioned above. The fifth stage is based on the premise that individual schools will adapt the innovation to their needs. It is only through a deep change and understanding of the C&R curriculum that the conceptual framework, based on a new stage-the fifth, the Adaptation stage-can be developed. In this chapter, the key findings will be presented in relation to the themes of the research questions. The literature review, conceptual framework and responses are considered in the findings.

6.1.1 Theoretical Framing of the Discussion

The purpose of this chapter is not simply to describe what the participants in this study said and experienced. The purpose is to interpret what they said and experienced to read the findings through the Adoption through Deep Change and Diffusion Model (ADCM) and to ask what the data tells us about how South African Foundation Phase teachers adopt and adapt the Coding and Robotics curriculum. Description and interpretation are different tasks, and this chapter is primarily concerned with the second. Each theme and subtheme discussed in the sections that follow is therefore examined not only for what it reveals about participants' lives and classrooms, but for what it reveals about the process of curriculum adoption itself and for what it adds to or challenges in the theoretical framework that guided this study.

The three themes that emerged from the data; Emotions, Stumbling Blocks and Adaptability are not three separate stories about three separate aspects of teachers' experience. They are three dimensions of a single process: the process of adopting and adapting a new curriculum under difficult conditions. The ADCM provides the theoretical language for reading them together. Rogers' (2003) Innovation Decision Process, which forms the first component of the ADCM, describes adoption as moving through five stages: knowledge, persuasion, decision, implementation and confirmation. Fullan's (1993) Theory of Deep Change, which forms the second component, argues that this process is never smooth or automatic, it requires teachers to develop a deep understanding of the change, to engage with it collaboratively

and to take personal ownership of it. The ADCM's fifth and final stage, the Adaptation Stage captures what this study found to be happening in South African classrooms: teachers not only adopting the curriculum but actively reshaping it to fit the realities of their schools.

6.2 Discussion of Findings

The discussion of the findings is presented in three sections below, each addressing a particular research question.

6.2.1 Emotions

The implementation and diffusion of the C&R curriculum in primary schools has provoked diverse emotions amongst teachers. This section provides discussions and recommendations on the subthemes of intimidation and frustration, perseverance, and hope that have emerged from the theme ‘Emotions’. Teachers' emotional responses to the C&R curriculum implementation ranged from apprehension and frustration to perseverance and optimism. This phenomenon aligns with Rogers' (2003) IDT, which suggests that emotional responses significantly influence the adoption of innovations. The conceptual framework utilised in the study proposed that teachers must participate collaboratively and continuously at all stages of the innovation's diffusion (Rogers, 2003), from the interest stage through to the adaptation stage. Therefore, this conceptual perspective is believed to offer a different strategy for analysing and understanding the tenuous relationship between strategies for managing curriculum diffusion and teachers' experiences in implementing the C&R curriculum. In this context, teachers’ experiences were captured as emotions which played a pivotal role in their decision to adopt the C&R curriculum. The discussions presented below emerged from the findings in response to research question one of this study: What are teachers’ current experiences with the implementation and diffusion of the C&R curriculum?

6.2.1 Discussions

When implementing the C&R curriculum, 7 out of 10 participants, particularly from quintiles 2, 3, and 4, reported experiencing negative emotions, such as frustration and intimidation. These emotions were mainly related to the participants' age and perceived lack of technological skills (Al-Mukhaini et al., 2021). Regarding participants' age, older teachers believed their age was a barrier to implementing, leading them to feel fear and frustration. These feelings of anxiety and frustration were also evident in research conducted by Hu et al (2022). In contrast to negative emotions, participants from quintile five schools expressed positive emotions, such as perseverance and hope, when implementing the C&R curriculum. These participants exuded certainty and fearlessness in their ability to adapt the C&R curriculum and celebrated its implementation as a means for personal and professional development.

The implementation of the C&R curriculum has elicited significant emotional responses from teachers. The findings underscore the importance of providing teachers with necessary support and resources to manage new subjects effectively and maintain a healthy work-life balance. In

accordance with the theories of Deep Change and Innovation Diffusion, substantial transformations are necessary to ensure widespread adoption and diffusion of the C&R curriculum. These transformations must address the challenges identified above, which directly affect teachers' emotions, as these emotions determine the level of adoption of this new curriculum.

6.3 Stumbling Blocks that Delay Transformation

The IDT, as premised by Rogers (2003), is that teachers' acceptance and knowledge of a curriculum determines the level of effectiveness of its diffusion, while the Theory of Deep change, according to Fullan (2004) states that for deep change to occur (the deep change being the diffusion of the C&R curriculum) there must be a deep understanding and deep learning of the phenomena under study. In deep learning, stumbling blocks must be identified. Stumbling blocks in this study were identified as challenges teachers face when implementing the C&R curriculum. These stumbling blocks play a critical role in determining whether an innovation is diffused. Teachers' experiences with the implementation and diffusion of the C&R curriculum in primary schools have been hampered by various stumbling blocks. These stumbling blocks, as identified by the participants, include a lack of technological resources, inadequate training, difficulty implementing group work, and a lack of inclusivity and accessibility within the C&R curriculum, which further exacerbated feelings of frustration.

6.3.1 Lack of Technological Resources

The findings showed that seven out of ten participants in quintiles 2, 3, and 4 lacked access to critical technical tools, such as computer laboratories and internet connectivity. The lack of resources greatly hindered the implementation of the C&R curriculum, as presented by the data. Participants in quintile five schools, on the other hand, had greater accessibility to technological resources. This exemplifies the underlying quintile-based discrepancies in resource distribution (Van Dyk & White, 2019). These findings resonate with Fullan's (1993) Theory of Deep Change, which emphasises the need for profound understanding and learning to facilitate meaningful change. The absence of these essential elements hindered the deep change required for successful implementation.

Eight out of ten participants received training; however, the efficacy and relevance of the C&R curriculum training were highly questionable, as this study revealed that the instruction was insufficient and incomprehensible to the typical teacher. These findings underscore the need for enhanced professional development for teachers, especially in schools classified in quintiles 2, 3, and 4. The professional development should focus on improving teachers' confidence and proficiency in utilising digital tools and executing the C&R curriculum. Addressing these challenges is crucial to ensuring effective implementation and promoting learner engagement.

This scarcity of resources significantly hinders the effective implementation of the C&R curriculum (Jantjies, 2019). Participants underscored the need for technological equipment and computer labs to teach C&R. 7 out of 10 participants reported not having such facilities, and safety

and security concerns surrounding technological equipment emerged as a significant challenge in the high-crime area. The deficiency of technological resources and concerns regarding safety and security have considerable ramifications for education. Participants indicated that a lack of pragmatic C&R experiences leads to learner disengagement and boredom. Furthermore, participants' inability to adequately teach the C&R curriculum hinders the development of crucial skills in learners.

6.3.2 Ineffective Training

The subtheme of inadequate training was evident in this study, with a considerable majority of participants (six out of ten) that experienced difficulty comprehending the DBE C&R training. The inadequate training was due to the excessive use of computer jargon by the facilitators, which many teachers found unfamiliar and could not understand. Participants emphasised the need for quality-driven training that caters to teachers with limited understanding of computer jargon, rather than training for the sake of doing it. The DBE's workshops, facilitated by professional IT specialists, were criticised by the participants for being too advanced and confusing. Participants suggested that training should be conducted by trainers who teach in a manner that is understandable and relatable to teachers.

Participants' experiences underscore the importance of effective teacher training for implementing the C&R curriculum. Research indicates that teachers often lack sufficient technical expertise, which can make teaching these subjects difficult (Hsu et al., 2022). A well-planned professional development programme is critical for equipping teachers with the relevant skills and knowledge to implement the C&R curriculum. This study revealed disparities in training opportunities, with teachers from higher quintile schools being more likely to receive specialised training in C&R (Moyo, 2024). Conversely, schools in lower quintiles lack the resources and support necessary to provide specialised training, resulting in a negative teacher-training experience.

6.3.3 Group Work in Overcrowded Classrooms

The implementation of the C&R curriculum in South African schools has highlighted the limitations of group work in overcrowded classrooms. The C&R curriculum emphasises the value of group work in fostering interpersonal skills such as problem-solving, cooperation, and interaction, as well as technical skills (DBE, 2020). However, the reality of overcrowded classrooms, with 45 to 50 learners, presents considerable hurdles to effective group work. Six individuals identified big class sizes as a significant barrier to learner participation and engagement in groups. The classroom arrangement was found inadequate for teaching C&R, with participants expressing difficulty giving complete attention to all groups due to the large number of learners. This is consistent with research findings that suggest teachers' capacity to facilitate group activities are weakened in large class sizes, resulting in lower levels of learner participation and cooperation (Antoniou et al., 2024).

Interestingly, four participants disagreed, claiming that class size did not influence the successful implementation of the C&R curriculum in group settings. These participants emphasised that the instructor's ability, confidence, and professional growth are key factors in determining

the success of group projects. This viewpoint was reinforced by Köhler's (2020) research, which indicates that class size is insignificant and that other factors, such as educator skill, resource availability, and favourable learning settings, have a bigger impact on learner performance. The study's findings underscore the necessity for teachers to use innovative techniques to support productive group work in overcrowded classrooms. This could include using technology, such as online collaboration platforms, to increase learner engagement and participation. Furthermore, the value of teacher professional development and support cannot be emphasised, since teachers must have the skills and confidence to handle large classes and promote effective group work.

6.3.4 Lack of Inclusivity and Accessibility Within the C&R Curriculum

The study's findings highlight serious concerns about the lack of diversity and accessibility in the C&R curricula. Despite the DBE's (2020) goal of creating an inclusive and accessible C&R curriculum for all learners, participants in this study reported that the C&R curriculum is not adaptable to learners from disadvantaged backgrounds.

According to the data, 70% of participants lacked the equipment and assistance required to deliver inclusive and accessible plugged activities (Graph 5.9.1(a)). Furthermore, 80% of participants stated that they needed training to adapt curriculum materials to learners with varied skills and needs (Graph 5.9.2(b)). These findings highlight the need for systemic changes in teacher preparation and resource allocation to ensure the C&R curriculum is inclusive and accessible to all learners.

Participants stated that learners from underprivileged backgrounds face significant hurdles in accessing C&R instruction due to limited resources, including hardware, software, and reliable internet connectivity. This supports the results of Van der Merwe and Barnard (2022), who identified major barriers to equitable technology inclusion and accessibility in South Africa's educational system.

The C&R curriculum's standard approach ignores learners' individual needs, particularly those with impairments or from low-income families. This contradicts South African policy's inclusive education principles, which advocate for curriculum adaptations to meet the needs of every learner (South African Department of Education, 2021). To summarise, the study's findings highlight the need for structural adjustments to ensure that the C&R curriculum is inclusive and accessible to all learners.

6.4 Bridging the Gap: Integrating Unplugged C&R to Address Technological Constraints and Nature Deficit

To effectively implement the C&R curriculum in South African schools, it is crucial to address the technological constraints and nature deficit faced by learners. According to the IDT, a deep understanding of the C&R curriculum is essential for effective diffusion.

6.4.1 Lack of Technological Resources

The shortage of technological resources, such as computer laboratories and internet connectivity, greatly impedes the effective implementation of the C&R curriculum. As revealed in the data presentation, the majority of participants teach in schools with limited or no access to technical tools. This is in keeping with previous research that has highlighted the issues schools face in resource-constrained situations (Jantjies, 2019; Van Dyk & White, 2019).

A lack of technological resources has serious consequences for teaching and learning. Participants expressed concern about their inability to physically demonstrate coding concepts to learners, which led to boredom and disengagement (PI-3). Furthermore, a lack of resources exacerbates the already significant discrepancies between schools in privileged and underprivileged neighbourhoods (Jones, 2021). The findings emphasise the importance of overcoming the constraints on teaching C&R, especially in resource-constrained settings. The lack of technological infrastructure, such as computer laboratories and internet access, poses a significant challenge. This is heightened by concerns about safety and security in South Africa, which has a high crime rate. The data gathered from questionnaires, interviews, and collage-making sessions emphasise the need for non-digital pedagogical approaches (unplugged) to teach C&R. The majority of participants teach in schools with limited or no access to technological resources, making it difficult to implement C&R effectively.

6.4.2 Unplugged C&R

According to research by Chen et al. (2023) and Demir (2021), unplugged C&R activities increase computational thinking and are especially useful in low-resource settings, as they eliminate the need for access to technological devices. Although unplugged C&R have gained popularity as an innovative and accessible starting point for computational thinking, teachers struggle to maintain learner engagement, as this study found. This may result in learners losing interest, especially when teachers rely on a limited set of unplugged resources or when activities lack variety or are not sufficiently challenging to gauge learners' interest (Chen et al., 2023; Erümit, 2020). Learners also want to learn C&R using technology, yet the majority of the participants in this research teach in schools without computer laboratories or internet access. This means that, while unplugged C&R is a successful method, it should be supplemented with plugged activities to keep learners interested. Multiple studies have found that learners prefer and are more motivated by plugged, technology-driven activities, and that unplugged activities often leave learners desiring to apply their knowledge on digital platforms (Erümit, 2020; Akiba, 2022).

The simultaneous desire for unplugged C&R (driven by resource constraints) and digital C&R (driven by learner engagement and 4IR imperatives) constitutes a productive theoretical tension that the ADCM illuminates rather than resolves. Within the DOI framework, this tension represents the gap between 'ideal adoption' (full technological implementation) and 'contextualised adoption' (adaptation to available resources). Fullan's (1993) Theory of Deep Change adds a further dimension: deep change requires that teachers not simply substitute digital with unplugged but develop a principled rationale for unplugged approaches that transcends resource scarcity affirming unplugged C&R as pedagogically valid

in its own right. This study thus proposes that the resolution to the unplugged-vs-digital tension lies not in choosing between the two but in developing a sequenced, contextually responsive pedagogy: unplugged approaches build foundational computational thinking concepts, which are then applied and extended through digital tools when resources allow. This constitutes a genuine curriculum design insight grounded in the ADCM's Adaptation.

6.4.3 Nature Deficit in Learners

This study revealed a subtheme of nature deficit in learners, underlining the significance of teaching C&R using non-digital pedagogical approaches (unplugged). Participants expressed concern that excessive screen time, as stimulated by C&R, is leading to a nature deficit in learners, a term introduced by Louv (2005). Participants observed that excessive screen time impairs learners' capacity to interact and collaborate, limiting their grasp of human values and gestures. This is consistent with research findings suggesting that excessive screen use may reduce social skills and lead to social isolation (Hinkley & Taylor, 2012). Furthermore, participants expressed concern that C&R is developing a future workforce unable to disconnect from their phones or engage in proper conversation with others. Participants stated that unplugged C&R can help learners by encouraging outdoor activities, hence reducing their nature deficit. Unplugged exercises can help children develop critical skills, such as fine motor and muscle control, which are often overlooked in a technology-driven curriculum. Participants underlined the importance of unplugged activities for building learners' skills, noting that learners must master skills beyond C&R, such as fine motor and muscular control.

To successfully integrate unplugged coding, teachers must have a thorough understanding of the C&R curriculum. The teacher further requires continuous training and support to properly execute unplugged C&R activities by addressing the resource constraints and nature deficit mentioned above. Learners are more likely to experience a more thorough and engaging learning experience.

6.5 Theme One – Adaptability

By using the Theory of DOI and Deep Change reviewed in Chapter Three, this study posits that the extent to which teachers take an interest in, evaluate, engage in trial runs, adopt and adapt C&R is dependent on the societal mindscapes, belief in the reform, best practice, collaboration, deep acceptance, and the support received from the innovation diffusion process and therefore on their ability to adapt.

6.5.1 Integrating C&R into Other Subjects

The predominant theme identified in addressing research question three was adaptability: Participants indicated that the field of C&R is characterised by continual evolution, necessitating a flexible curriculum. The findings of this study demonstrate the diversity linked to the incorporation of C&R into the C&R curriculum, with participants emphasising the interdisciplinary nature of these subjects, which combine principles from Mathematics, Physics, Technology, Engineering, and Language Arts (Tshabalala & Mthembu, 2022). This viewpoint challenges the existing distribution of C&R within the Life Skills educational domain (DBE, 2021).

Participants expressed significant concern about the unreasonable allocation of time for C&R only within the Life Skills curriculum. They argued that focusing solely on Life Skills would deprive learners of critical competencies required for their overall development, particularly during the Foundation Phase. Instead, participants suggested that using time from the English, Mathematics, and Life Skills curriculum-not just Life Skills - to teach C&R would be more reasonable and beneficial to learners.

The study's findings highlight the need to include C&R in the Life Skills curriculum while respecting its connections to other topics. Participants underlined that C&R involve problem-solving in Mathematics and reading comprehension in English. As a result, allocating time from the English and Mathematics curricula would allow for a more comprehensive and integrated approach to learning. This finding is consistent with Rogers' (2003) IDT, which suggests that compatibility with existing values and practices is crucial for the adoption of innovation. The incorporation of diverse activities in the C&R curriculum enhances its compatibility with teachers' existing values and practices.

The study's key findings have significant implications for policymaking. The DBE should rethink 's placement in the C&R curriculum, considering its multidisciplinary nature and the necessity to maintain the integrity of the Life Skills topic. By doing so, teachers may provide learners with an extensive and inclusive education that equips them for the twenty-first century.

6.5.2 Use of Available Resources

The conceptual framework of this study suggests techniques for adapting the C&R curriculum diffusion process to foster deep change. This requires implementing the best practices highlighted by the participants in this study to adjust the C&R curriculum to meet each school's specific needs. Notably, one of the best practices identified by participants is the effective use of available resources to support the development of problem-solving and critical thinking skills in learners, seamlessly integrating them into lesson plans. Research indicates that effective curriculum adaptation relies on social adaptability and the integration of limited resources, enabling schools to implement innovation despite resource constraints (Fullan, 2021; Voogt & Knezek, 2020). The workshops on C&R, specifically workshops 2, 3, and 4, focused on leveraging limited resources to enhance teaching practices. Through unplugged coding activities and hands-on tasks such as designing cardboard robots and simulating crane operations with everyday objects, participants developed problem-solving, critical thinking, and creativity. The activities encouraged resourcefulness and adaptability, demonstrating that effective C&R education can be achieved despite resource constraints. These methodologies correspond with research indicating that unplugged activities foster computational thinking and improve learner engagement in resource-limited environments (Kalelioglu & Gülbahar, 2020; Brackmann et al., 2017). Participant feedback from focus group interviews and reflective questionnaires highlighted the positive impact of these workshops on their teaching approaches and learner outcomes. Practical professional development, such as that provided by the workshops in this study, also aligns with other studies indicating that workshops enhance teacher confidence, pedagogical understanding, and the ability to effectively integrate novel curriculum (Darling-Hammond et al., 2020; Avalos, 2021).

The workshops effectively provided participants with the necessary knowledge and confidence to teach C&R with limited resources. By emphasising creativity, adaptability, and resourcefulness, participants created engaging and successful learning experiences in their classrooms. Hands-on activities helped learners enhance their problem-solving skills. The findings are consistent with previous studies indicating that limited resources can promote creativity and flexibility in teaching techniques (Blikstein, 2020; Sengupta et al., 2020). Overall, the workshops proved the ability to improve educational outcomes in C&R using novel teaching approaches in resource-constrained environments.

6.5.3 Pedagogical Transformation

The integration of C&R into the elementary school curriculum in South Africa opens up several opportunities for innovative, holistic learning. However, it presents substantial obstacles, especially in resource-constrained contexts. The study found that contextual learning and pedagogical transformation are critical for increasing learner motivation and participation. The findings indicate that contextual learning and pedagogical transformation are essential for increasing learner motivation and participation, and that teaching methods can be tailored to varied circumstances and learner demands. The workshops illustrated how outdoor C&R activities can encourage a more integrated, holistic approach to teaching and learning. South African primary schools. However, it emphasises the need for a more adaptive and inclusive approach to teaching and learning, one that utilises available resources, incorporates outdoor learning activities, and addresses systemic issues. By taking this approach, schools may give learners with disabilities an integrated and inclusive education that prepares them for success in the twenty-first century.

The study examined how the teachers experienced the process of curriculum diffusion for C&R. By using the Theory of DOI and deep change reviewed above, this study posits that the extent to which teachers take an interest in, evaluate, engage in trial runs, adopt and adapt C&R is dependent on the societal mindscapes, belief in the reform, best practice, collaboration, deep acceptance and the support received from the innovation diffusion process and therefore on their ability to adapt. This led to the development of the conceptual framework that encompassed the study. The conceptual framework is premised on the notion that the adaptation and optimisation of the C&R curriculum outcomes are facilitated by integrating appropriate diffusion of the four stages of innovation and deep learning, which will result in the adaptation stage. The findings suggest that the participants have a deep understanding of the C&R curriculum; hence, a significant change occurred: the acceptance and adaptation of the C&R curriculum. The integration of the constructs of the diffusion process and the proponents of deep change was critical to mobilise the support for the innovation, by making information available about the innovation during the workshops conducted in the study so that the teachers as implementers of the innovation understand what the best practices are and how to go about adapting it to meet the individual needs of the school-the best practices as discussed above range from leveraging limited resources to pedagogical changes.

6.6 Cross-Theme Synthesis: Emotions, Stumbling Blocks and Adaptability as an Integrated Account of Teacher Change

The three themes that emerged from this study; Emotions, Stumbling Blocks and Adaptability are not separate findings. They are three stages of a single change process that the ADCM maps. Teachers first formed emotional responses to the C&R curriculum ranging from fear and frustration in lower-quintile schools to perseverance and hope in higher-quintile schools, before they could decide whether to engage with it at

all. These emotions were not irrational; they were the natural response of professional teachers being asked to implement a curriculum for which they had not been adequately prepared. The structural barriers documented in Theme Two; the lack of technology, ineffective training and overcrowded classrooms then intensified those emotions by confirming teachers' fears in practice. However, it was precisely these barriers that made the adaptive strategies of Theme Three necessary. Teachers who lacked computer laboratories had to invent unplugged alternatives. Teachers who received poor training had to develop their own approaches. The stumbling blocks did not stop the change process they shaped it.

What makes this account theoretically significant is the simultaneous presence of fear and adaptability in the same participants. Teachers who felt intimidated by C&R were the same teachers who, by the end of the study, were designing outdoor coding activities and integrating C&R across subjects. Fullan (1993) describes this as productive dissonance the discomfort that arises when a teacher is genuinely negotiating between who she already is as a professional and who the new curriculum requires her to become. It is uncomfortable because it is real. The ADCM captures this reality by treating adaptation not as the end point of a smooth progression but as the outcome of a recursive, emotionally demanding process. The journey from emotional resistance through structural obstacle navigation to adaptive practice is the ADCM in action and it is the most coherent account this study can offer of how curriculum change actually happens for South African Foundation Phase teachers working under conditions of inequality.

6.7 Conclusion

The central theoretical insight that emerges from reading the three themes together through the ADCM is this: curriculum adoption in a context of inequality is not a linear progression. It is a recursive, emotionally mediated process in which teachers move back and forth between the stages of the ADCM, depending on the structural conditions they face, the support they receive and the personal and professional resources they can draw on. This finding challenges any model of curriculum adoption that treats the stages as a neat sequence as though a teacher who has been trained once has been persuaded, and a teacher who has been persuaded has decided, and a teacher who has decided has implemented. The data from this study shows clearly that this is not how adoption works in South African quintile-stratified schools. The ADCM, by incorporating both the diffusion stages of the IDT and the depth requirements of Fullan's (1993) theory, is better equipped than either theory alone to describe and explain what actually happens when teachers in under-resourced contexts encounter a new and demanding curriculum mandate. The sections that follow examine each theme in detail, with this theoretical map as the guide.

In conclusion, this study provides a nuanced understanding of the challenges surrounding the implementation and diffusion of the C&R curriculum in South African primary schools. The study's findings provide a rich tapestry of insights that could help shape policies and initiatives to increase the implementation and dissemination of this unique curriculum. Recognising the complexities and challenges involved, teachers and policymakers can collaborate to develop a more effective, integrated approach to teaching the C&R curriculum.

CHAPTER SEVEN –Findings, Recommendations and Propositions: Towards a More Equitable C&R Curriculum“The Code has been Cracked”

7.1 Introduction

This chapter presents the study's conclusion by synthesising the key findings in relation to the research questions and the theoretical and conceptual frameworks that guided the study. The chapter also highlights the study's contributions to knowledge, outlines recommendations, and suggests future research directions. The overarching aim of this study was to examine how teachers experience, adopt and adapt the C&R curriculum in South African primary schools, particularly within resource-constrained contexts.

The study was framed using Rogers’ (2003) DOI Theory and Fullan’s (2005) notion of Deep Change Theory, which together provided a lens for understanding the process by which teachers engage with new curricular reforms. These theories helped illuminate the stages of innovation adoption – from awareness, evaluation, and trial, to adoption, and eventual adaptation – while also explaining the deeper pedagogical shifts required for sustainable curriculum integration. These two theories combined to form the study's conceptual framework. The study was guided by three research questions, of which themes and subthemes emerged. Each research question is discussed below, followed by the corresponding answers to the research questions.

7.2 Summary of Key Findings

The first research question examined teachers' experiences with the implementation and diffusion of the C&R Curriculum. The introduction and dissemination of the C&R curriculum in primary schools has elicited a range of reactions from teachers. They are discussed below as the themes that emerged.

7.2.1 What are Teachers’ Current Experiences with the Implementation and Diffusion of the C&R Curriculum?

Teachers’ emotional reactions to the C&R curriculum implementation were diverse, with negative feelings (frustration and intimidation) more common among older teachers and those from schools in quintiles 2, 3, and 4. Teachers from quintile 5 schools reported positive emotions (perseverance and hope) and described the C&R curriculum as a chance for personal and professional development. The study emphasised the importance of personalised support and professional development for teachers, particularly those in schools in quintiles 2, 3, and 4. The study's findings are consistent with Rogers' (2003) IDT, which emphasises the importance of emotional responses in the adoption of innovations.

Recommendations

Policymakers must recognise the emotional impact of the C&R curriculum on teachers and ensure that adequate support systems are in place to assist successful implementation. The findings of this study highlight the importance of structural and substantive changes in the education sector

to encourage the effective adoption and distribution of the C&R curriculum across schools. Sustained investment in teacher development, adequate funding, and continued policy alignment are thus essential for achieving the desired educational reform and ensuring the long-term viability of this new curriculum (Tang et al., 2023).

7.3 Why Should Non-Digital Pedagogical Approaches (unplugged) be Adapted to Teach C&R?

The second research question investigated the reasons behind adapting non-digital pedagogical approaches (unplugged) to teach the C&R curriculum. The themes that merged were stumbling blocks and bridging the gap: integrating unplugged C&R to address technological constraints and nature deficit. These themes are closely linked, as teachers encountered various stumbling blocks when implementing traditional pedagogical approaches; hence, the need for non-digital pedagogical approaches (unplugged) to be adapted to teach the C&R curriculum.

7.3.1 Stumbling Blocks

The findings revealed several stumbling blocks that hindered the effective implementation of the C&R curriculum, including a lack of technological resources, inadequate training, difficulty implementing group work in overcrowded classrooms, and a lack of inclusivity and accessibility within the C&R curriculum. To mitigate these challenges, the study proposes creating a diverse set of unplugged resources and including unplugged C&R activities within a realistic, practical curriculum that utilises everyday resources.

Key Findings

This study's findings highlight several major problems in implementing the C&R curriculum. First, schools in quintiles 2, 3, and 4 reported limited access to critical technology tools, which hampered effective curriculum implementation (National Education Collaboration Trust, 2021). Second, participants reported that the training was mostly unsuccessful, relying excessively on technical jargon and failing to include practical, accessible teaching tactics. Furthermore, group work was found to be problematic in overcrowded classrooms, where limited space and large learner populations made it impossible for teachers to manage group dynamics and provide sufficient support to all learners (Frontiers, 2025). Finally, issues of inclusivity and accessibility emerged as central concerns, with the C&R curriculum proving to be less accessible to learners from disadvantaged backgrounds due to insufficient resources and inadequate learner support mechanisms (Frontiers, 2025).

Recommendations

The Department of Basic Education should prioritise the provision of technological resources, including computer laboratories and reliable internet connectivity, to support the effective implementation of the Coding and Robotics curriculum. To safeguard these resources, schools must establish, revise, and consistently review safety and security measures that ensure the protection and sustainability of technological

equipment. The successful rollout of the curriculum further requires systematic monitoring and evaluation. This process should be conducted regularly by curriculum specialists, such as subject advisers, in order to identify gaps and inform continuous improvement.

In addition, the curriculum would benefit from the simplification of computer-related terminology and the adoption of more accessible teaching approaches. Making content more relatable will enhance teachers' comprehension of the subject matter and strengthen their ability to convey concepts confidently to learners. Creating an environment in which teachers feel secure, competent, and supported is essential for the meaningful integration of technology into classroom practice.

Teacher professional development should be prioritised through ongoing training and support that build the necessary skills for facilitating effective group work, particularly in large classes. Teachers should also be encouraged to use innovative teaching strategies, including the integration of technology, to increase learner engagement and participation. Strengthening classroom management practices through targeted training and appropriate resources is equally important for ensuring that group work is productive and well-structured.

Finally, the Coding and Robotics curriculum should be revised to incorporate principles of inclusive education and to respond adequately to the diverse needs of learners, including those experiencing learning barriers. Such revisions will help ensure that the curriculum is equitable, responsive, and accessible to all learners.

These stumbling blocks hinder the effective implementation of the C&R curriculum and underscore the need for policymakers and teachers to address them through targeted interventions and support. The study emphasises the need for policymakers and teachers to address systemic issues that impede the effective implementation of the C&R curriculum. The findings highlight the need for sufficient teacher training, resources, and support to ensure successful implementation. The study emphasises the need for a more inclusive and accessible curriculum that meets the different requirements of learners (Zivanayi & Malinga, 2025).

7.3.2 Bridging the Gap: Integrating Unplugged C&R to Address Technological Constraints and Nature Deficit.

Another theme that emerged when responding to Research Question Two was: Bridging the Gap: Integrating Unplugged C&R to Address Technological Constraints and Nature Deficit. The results of this study suggest that non-digital pedagogical approaches (unplugged) particularly unplugged C&R, are critical for the successful implementation of the C&R curriculum in South African schools. This immediately addresses Research Question Two, which attempted to explain why unplugged methodologies should be used while teaching C&R. The findings of this study indicate that non-digital pedagogical approaches (unplugged), particularly unplugged C&R, are crucial to the successful implementation of the C&R curriculum in South African schools. This directly addresses Research Question Two, which sought to explain why unplugged approaches should be employed while teaching the subject.

Key findings

Infrastructure constraints, such as a lack of computer laboratories, poor internet connectivity, and insufficient secure facilities, severely impede C&R implementation (Zivanayi & Malinga, 2025). According to the IDT, the absence of these enabling tools limits teachers and learners from fully adopting, experimenting with and implementing the C&R innovation (Rogers, 2003). Simultaneously, using unplugged approaches promotes holistic learner development (Learning.com, 2024). These approaches not only reduce the hazards associated with excessive screen time but also foster essential developmental abilities, including fine motor coordination, physical activity, and social teamwork, promoting balanced learner development (Mhlongo, 2025). Furthermore, non-digital pedagogical approaches (unplugged) play an important role in addressing learners' nature deficits, providing a more comprehensive rationale for their integration into teaching and learning practices (Learning.com, 2024).

Recommendations

To address persistent disparities in access to technology, increased financing and targeted support should be directed toward resource-constrained schools. Such investment is essential to improving technical infrastructure, including the establishment of computer laboratories and the provision of reliable internet connectivity. Ensuring equitable access to these resources will support the effective implementation of the Coding and Robotics curriculum across diverse school contexts.

Furthermore, the curriculum should provide a balanced combination of plugged-in and unplugged activities. This approach will promote meaningful learning while fostering a healthy, ethical, and respectful engagement with technology. A balanced curriculum also ensures that learners develop computational thinking skills irrespective of the availability of digital devices, thereby enhancing inclusivity and supporting the broader aims of technological education. This information provided highlights that unplugged C&R is not simply a temporary solution for under-resourced environments but a strategic educational imperative. It addresses structural educational inequities, fosters diversity, and mitigates the adverse impacts of digital saturation.

7.4 How do Teachers Adapt the C&R Curriculum in the Context of Limited Resources and Curriculum Constraints?

The findings indicated that adaptability was the primary theme underlying participants' experiences, reflected in three interconnected domains: curricular integration, utilisation of available resources, and pedagogical transformation.

Key Findings

curriculum integration requires embedding the subject across disciplines such as Mathematics, English, and Life Skills, rather than limiting it to a single subject area (Woo, 2025). This technique allows learners to establish meaningful connections between computational thinking and other academic skills. Furthermore, teachers' resourcefulness and imagination play a critical role in increasing learner involvement (Maqoqo, 2024).

Teachers who use everyday items and participate in collaborative workshops not only inspire learners' creativity but also boost their own confidence in teaching the subject. Furthermore, the educational revolution connected with C&R works best when inclusive and immersive teaching methods are used (Díaz-Boladeras et al., 2025). However, systemic obstacles such as inadequate infrastructure, limited internet connectivity, and insufficient support for learners with disabilities hinder the full realisation of these benefits (Maqoqo, 2024; Woo, 2025). Addressing these structural challenges is essential to ensure equitable access and sustainable integration of C&R in schools.

Recommendations

The Department of Basic Education should review the current allocation of teaching time for Coding and Robotics, which is presently drawn exclusively from the Life Skills subject. Given the strong conceptual links between Coding and Robotics and subjects such as Mathematics, English, and other learning areas, a more equitable redistribution of instructional time across these subjects is warranted. Such a revision would ensure a more balanced and integrated curriculum that reflects the interdisciplinary nature of Coding and Robotics.

Teachers should also be encouraged to cultivate resourcefulness and adaptability by using the materials available to them in creative ways. Employing innovative approaches to explain complex concepts can make learning more engaging, inclusive, and accessible to all learners. Additionally, collaborative learning should be strengthened through sustained group-based workshops that promote participation, shared problem-solving, and collective professional growth. These collaborative efforts can enhance the overall effectiveness of teaching and support continued improvement in the delivery of the Coding and Robotics curriculum. Teachers should be supported in implementing experiential and outdoor learning activities as part of C&R. Policymakers must address systemic inequalities, ensuring inclusivity for learners with disabilities and disadvantaged communities.

7.5 Propositions

The following propositions are scholarly claims that this study makes based on its findings. They are different from recommendations. A recommendation tells someone what to do. A proposition makes a claim about what the findings mean for theory, for policy, and for our understanding of education. Each proposition grows directly out of what the ten participants in this study experienced and what the data showed. Together, they represent the study's contribution to knowledge

Proposition 1: Emotion in curriculum adoption is shaped by school quintile

This study proposes that a teacher's emotional response to a new curriculum such as fear, frustration, hope, or confidence is significantly shaped by the socioeconomic context of the school in which they work. In this study, teachers from quintile 2, 3, and 4 schools were more likely to feel intimidated and frustrated. Teachers from quintile 5 schools were more likely to feel hopeful and confident. This pattern was consistent and clear across the data. It suggests that dominant theories of curriculum adoption including Rogers' (2003) Diffusion of Innovation Theory do not fully

account for the role that structural inequality plays in shaping how teachers respond to new curriculum demands. A model that treats all teachers as facing the same starting conditions will fail to explain why the same curriculum produces such different emotional responses across different school contexts.

Proposition 2: The Adaptation Stage is a necessary part of curriculum adoption in unequal systems

This study proposes that curriculum adoption in a context of inequality cannot be fully understood using existing models that end at implementation. Rogers' (2003) Diffusion of Innovation Theory describes adoption as a five-stage process: knowledge, persuasion, decision, implementation, and confirmation. This study argues that a sixth stage is required; the Adaptation Stage in which teachers actively reshape a curriculum to fit the specific needs, resources, and realities of their school. The Adaptation through Deep Change and Diffusion Model (ADCM) developed in this study formalises this stage and demonstrates that it is not an exception to the adoption process but a necessary and expected part of it, particularly in contexts where the conditions assumed by the original curriculum designers do not exist. Teachers in this study did not fail to implement the curriculum they adapted it. That is a different and more theoretically significant finding.

Proposition 3: Unplugged C&R is a valid pedagogy, not a substitute for digital teaching

This study proposes that unplugged Coding and Robotics approaches represent a legitimate and effective pedagogical choice, not merely a workaround for schools that lack technology. The evidence from this study shows that teachers who used unplugged activities, including outdoor tasks, physical manipulation of materials, and offline problem-solving reported higher levels of learner engagement, better collaborative learning, and a stronger sense of teaching confidence. These outcomes were not the result of making do with what was available; they were the result of teachers making deliberate, creative, and evidence-informed pedagogical decisions. Louv's (2005) nature deficit concept, integrated into the ADCM, further supports the claim that unplugged and outdoor C&R approaches contribute to learner wellbeing and development in ways that screen-based learning does not. The formal C&R curriculum should therefore recognise unplugged approaches as a primary pedagogical mode not a backup option.

Proposition 4: Deep change in curriculum adoption requires sustained relational support, not single training events

This study proposes that meaningful and lasting adoption of the C&R curriculum cannot be achieved through short, one-off training sessions. Fullan's (1993) Theory of Deep Change argues that real change in how teachers think and teach requires time, collaborative engagement, and a willingness to question existing beliefs and practices. The findings of this study support this argument clearly. Teachers who participated in five consecutive, structured, hands-on workshops showed markedly different post-intervention responses compared to their pre-workshop attitudes. They reported greater confidence, more creative thinking about how to teach C&R, and a stronger belief that the curriculum could be adapted to fit their context. In contrast, the DBE's initial training described by most participants as a single, jargon-heavy event did not produce lasting

change. This study therefore proposes that professional development for C&R must be sustained, relational, and practice-centred to produce the kind of deep change that effective curriculum adoption requires.

Proposition 5: C&R curriculum policy must account for the realities of the quintile system to be equitable

This study proposes that the successful implementation of the Coding and Robotics curriculum in South Africa is inseparable from a frank engagement with the inequalities embedded in the quintile system. The quintile system was designed as a funding mechanism. In practice, it has created a two-tier educational landscape in which the conditions for learning technology access, class size, teacher training, and infrastructure differ so dramatically that the same curriculum mandate produces fundamentally different educational experiences depending on which quintile a school falls in. This study makes the claim that a curriculum policy document that does not acknowledge and respond to these differences is not a universal curriculum it is a curriculum designed for quintile 5 schools, rolled out to all. For C&R to be genuinely equitable, policy must include differentiated implementation pathways, resource provisioning standards that are quintile-sensitive, and assessment models that do not penalise schools for structural disadvantages they did not create.

The five propositions above identify what this study claims to be true, based on its findings and theoretical framework. The recommendations that follow describe what should be done in response to those claims. Each recommendation is grounded in one or more of the propositions above, meaning the recommendations are not a separate list of suggestion but practical responses to the study's scholarly arguments.

7.6 Contributions to Knowledge

This study contributes to knowledge in three key ways:

Theoretical Contribution – The study advances theoretical knowledge by integrating the DOI (Rogers, 2003) with the concept of deep transformation (Fullan, 2005). While DOI Theory has typically explained how innovations spread across social systems, its application to deep change emphasises the need for long-term, transformative changes in teacher beliefs, practices, and attitudes. This study integrates DOI Theory with the concept of deep change to develop a conceptual framework for adaptation, offering new insights into how teachers engage with curriculum reform beyond C&R. This new conceptual framework is called the Adoption through Deep Change and Diffusion Model.

Curriculum Contribution – It challenges the confined time allocation for the Life Skills subject used to teach C&R, presenting evidence of its interdisciplinary potential and the need to increase the time allocation by integrating C&R into English and Mathematics as well. According to participants, integrating C&R into English and Mathematics has the potential to expand learning opportunities, foster interdisciplinary connections, and provide more equitable access to knowledge. The study contributes to curriculum design discussions in South Africa by advocating greater time allocation and greater integration of the C&R curriculum. It gives a compelling case for reorganising the implementation of C&R to reflect its multifaceted benefits in improving literacy, logical reasoning, and problem-solving abilities (Wing, 2006; Mishra & Yadav, 2013).

Pedagogical Contribution - The results show that innovative and resourceful teaching methods can promote successful learning in settings with limited resources. In addition to addressing inadequate infrastructure, teachers reported success with unplugged approaches, common materials, and collaborative peer-learning techniques, which encouraged learner participation and creativity. These results add to the corpus of research that highlights the value of contextualised pedagogy in fostering 21st-century skills, especially in settings with limited resources (Papert, 1993; Voogt et al., 2020). The study also shows how important pedagogical adaptation is to maintaining reform, as teachers who used inclusive, flexible, and learner-centred approaches were better equipped to get over structural obstacles and meaningfully engage learners.

7.7 Future Research Directions

The study highlights areas where future research is necessary, such as:
Longitudinal studies are required to track how teachers' attitudes, competencies and instructional methods change over time as they implement the C&R curriculum. Short-term studies risk confusing early adaptation issues with long-term outcomes.
A longitudinal panel methodology utilising ongoing observations and interviews could facilitate the assessment of the sustainability of initial professional development advancements, changes in teacher perceptions, and the dissemination of the C&R curriculum among schools over time, particularly in schools where resource disparities may influence different adoption patterns amongst teachers implementing the C&R curriculum. Inclusive Education – Although there is increasing interest in C&R for inclusive classrooms, limited research thoroughly investigates its adaptation for learners with impairments or in under-resourced environments (Díaz-Boladeras et al., 2025). Future studies are required to investigate co-design methodologies, assistive technologies, customised curriculum, and teacher scaffolding techniques that facilitate equal access. Policy Impact Studies: The time allocation and curriculum-placement policy decisions regarding the amount of instructional time allotted and whether C&R is presented as an independent subject or integrated into other subject areas may significantly impact learner achievement and teacher motivation. To evaluate trade-offs, future studies should implement cognitive improvements, and assessments should take into account systemic measures of inequality and accessibility, the impact on teacher effort, and the marginalisation of other subjects.

7.8 Limitations

The sample comprised only primary school teachers in South Africa; hence, the study's findings may not be generalisable to other contexts. Future research should explore the implementation and diffusion of the C&R curriculum across different contexts, including secondary schools and other countries. Additionally, future research could investigate the impact of the C&R curriculum on learner outcomes and the development of essential skills.

7.9 Conclusion and Final Thoughts

Unplugged C&R are essential within the South African setting. Finally, this study sheds light on the barriers to effective implementation of the C&R curriculum in South African primary schools. The findings highlight the importance of collaboration among policymakers, teachers and

researchers to address these challenges and ensure that all learners have access to a high-quality education that prepares them for success in the twenty-first century. It provides an inclusive, realistic, and comprehensive approach to teaching the C&R curriculum in settings where technical resources are restricted and learners are at risk of digital overexposure. When carefully conceived and implemented, unplugged approaches not only bridge the digital gap but also develop learners who are adaptable, collaborative, and possess both technological and non-technological skills. Finally, incorporating unplugged pedagogy ensures that the C&R curriculum meets its overarching goal: educating all learners-not just those from wealthy backgrounds-for meaningful involvement in the digital future.

The study concludes that teachers' adoption and adaptation of C&R was shaped by both internal (beliefs, values, pedagogical practices) and external (policy frameworks, resource availability, systemic support) factors. The conceptual framework developed from this study illustrates that adaptation is a staged process, moving from awareness through adoption to eventual contextualisation. The workshops conducted during the study played a pivotal role in facilitating this process by providing teachers with information, best practices, and opportunities for collaborative problem-solving. Teachers demonstrated resilience and creativity, showing that effective adaptation is possible even under constrained conditions. In sum, the study shows that the success of C&R depends not only on policy directives but also on teachers' ability to enact deep pedagogical change supported by systemic and collaborative structures.

This study provides an in-depth understanding of the issues surrounding the implementation and diffusion of the C&R curriculum in South African primary schools. The study's findings provide a rich tapestry of insights that could help shape policies and initiatives to increase the implementation and dissemination of this unique curriculum. Recognising the complexities and challenges involved, teachers and policymakers can collaborate to develop a more effective, integrated approach to teaching the C&R curriculum.

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APPENDIX A - Turn it in Report

Improving the Implementation and Teaching of the Coding and Robotics Curriculum in Primary Schools: Teachers' Experiences

ORIGINALITY REPORT

10%	7%	2%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	researchspace.ukzn.ac.za Internet Source	2%
2	Submitted to University of KwaZulu-Natal Student Paper	1%
3	Averil Gorrah, Francois Papers. "chapter 12 Implementation of Coding and Robotics in South African Public Schools, Fostering Teachers' Self-Directed Learning", IGI Global, 2024 Publication	1%
4	repository.up.ac.za Internet Source	1%
5	hdl.handle.net Internet Source	1%
6	Submitted to Taylor's Education Group Student Paper	<1%
7	José A. García-Avilés. "Diffusion of Innovation", Wiley, 2020 Publication	<1%
8	uir.unisa.ac.za Internet Source	<1%

9	scholar.sun.ac.za Internet Source	<1%
10	inspire.africa Internet Source	<1%
11	Submitted to University of Johannsburg Student Paper	<1%
12	caps123.co.za Internet Source	<1%
13	vital.seals.ac.za:8080 Internet Source	<1%

APPENDIX B- Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL ™
INYUVESI YAKWAZULU-NATALI

06 November 2024

Pranitha Chunder (204004663)
School of Education
Edgewood Campus

Dear P Chunder,

Protocol reference number: HSSREC/00007730/2024
Project title: Improving the implementation and teaching of the coding and robotics curriculum in primary schools: Teachers' experiences
Degree: PhD

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 06 September 2024 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

Incidents of adverse events and serious adverse events (AEs and SAEs) should be reported in writing to HSSREC, the study sponsors, and any regulatory authority (where appropriate), within 7 working days of the occurrence for local sites and 14 days for all other South African sites.

This approval is valid until 06 November 2025.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)
/nng

APPENDIX C-Permission to Conduct Research

KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE HEAD OF DEPARTMENT

Private Bag X 9 137, PIETERMARITZBURG, 3200 **Ref No.: 2/4/8/124**
Anton Lembede Building, 247 Burger Street, Pietermaritzburg, 3 201
Email: buyi.ntuli@.gov.za **Tel:** 033 392 1051 **Enquiries:** Mrs B. T. Ntuli

Mrs Pranitha Chunder
[redacted]
PHOENIX

Dear Mrs Chunder

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"IMPROVING THE IMPLEMENTATION AND TEACHING OF THE C&R CURRICULUM IN PRIMARY SCHOOLS: TEACHERS' EXPERIENCES:"**, in the KwaZulu-Natal Department of Education institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from **13 March 2024 to 31 August 2026**.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Mrs Buyi Ntuli at the contact numbers above.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

[redacted]

Mr G.N. Ngcobo

Head of Department: Education Date: 13 March 2024

GROWING KWAZULU-NATAL TOGETHER

APPENDIX D - Request for Permission to Conduct Research

LETTER TO THE PRINCIPAL

To: The Principal

REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT YOUR SCHOOL

My name is Pranitha Chunder, and I am conducting research as part of the University of KwaZulu-Natal's PhD programme. This letter requests permission to utilise your school as my research site. The study involves research exploring the implementation of C&R. The aim and purpose of this research are to develop ways to improve the current curriculum so that it is fit for purpose in a South African context. The study is expected to enrol 10 Foundation Phase educators who will engage in C&R Unplugged training workshops. It will involve educators attending 5 workshops, of which the C&R curriculum will be explained, and specific sections from the C&R curriculum will be explored. The study is expected to span three weeks, comprising five workshops held for 2 hours each. I require a single classroom to conduct this research. Any equipment that is required to conduct the research will be provided by the researcher.

The study will be conducted outside of teaching time; hence it will not compromise teaching time in any way. The date and times of the workshops will be properly communicated to you well in advance. The study will benefit you by providing your teachers with the tools they need to properly implement the C&R curriculum, utilising cost-effective ways to manage and teach it. This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number HSSREC/00007730/2024)

For more information and questions about the study, you may contact the researcher or the research supervisor at the following details:

Researcher: Pranitha Chunder: [redacted]
Supervisor: Dr ZHW Dube-Xaba: Tel No. (031) 2603679; [redacted]
Supervisor: Dr Reginald Govender: Tell No. [redacted]: govenderr4@ukzn.ac.za
Research Office: P. Mohun, HSSREC Research Office, Tel No. 031 260 4557 Email:

mohunp@ukzn.ac.za

Your cooperation will be highly appreciated

Pranitha Chunder (Researcher)

PERMISSION TO CONDUCT RESEARCH

Your letter titled "Request to conduct research at the school" has reference. Please be informed that you are granted a permission to conduct your research in our school.

Principal Signature _____

Date _____

SCHOOL STAMP

APPENDIX E - Application for Ethics Approval

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

APPLICATION FOR ETHICS APPROVAL
For research with human participants

Information Sheet and Consent to Participate in Research

Date: 3/03/2024

Dear sir/mam

My name is Pranitha Chunder, and I am currently a PhD student at University of KZN.

You are being invited to consider participating in a study that involves research exploring the implementation of C&R. The aim and purpose of this research is to develop ways of improving the current curriculum so that it is fit for purpose in a South African context. The study is expected to enrol 10 foundation phase educators who will engage in C&R Unplugged training workshops. It will involve you attending 5 workshops of which the C&R curriculum will be explained and specific sections that you will be teaching in your class will be explored. The duration of your participation, if you choose to enrol and remain in the study, is expected to exceed 3 weeks, comprising five workshops of 2 hours each.

The study will be conducted outside of teaching time; hence it will not compromise teaching time in any way. The date and times of the workshops will be properly communicated to you well in advance. The study will benefit you as it will provide you with the tools you require to properly implement C&R curriculum by utilising cost-effective ways to manage and teach the C&R curriculum. This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number_____).

In the event of any problems or concerns/questions you may contact the researcher at [redacted] or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 – Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Participation in the study is voluntary, and you have the right to anonymity and a choice to withdraw at any stage during the research without any prejudices. Further to this, you have a right to decline certain questions that you feel you are not willing to answer. Please note that in the event of refusal/withdrawal of participation you will not incur penalty or loss of treatment or other benefit to which you are normally entitled. If you decide that you are unable to continue further with the study, kindly inform the researcher and your participation will be withdrawn. Should you wish for anonymity your name and the research sites will be disguised using false names to protect your confidentiality.

There is no other cost that you will incur in engaging in this research other than driving to the venue which will be centrally located. You will receive resources of which you are free to utilise within your classroom.

CONSENT

I_____ have been informed about the study entitled Improving the implementation and teaching of the C&R Curriculum in Primary Schools: Teachers' Experiences by Pranitha Chunder.

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction. I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

I have been informed about any available compensation or medical treatment if injury occurs to me as a result of study-related procedures.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher via email: [redacted]

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001
Durban
4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 – Fax: 27 31 2604609

Email: HSSREC@ukzn.ac.za

I hereby provide consent to:

Audio-record my interview / focus group discussion YES / NO
Video-record my interview / focus group discussion YES / NO
Use of my photographs for research purposes YES / NO

_____ _____
Signature of Participant Date

_____ _____
Signature of Witness Date
(Where applicable)

_____ _____
Signature of Translator Date
(Where applicable)

APPENDIX F- Questionnaire's

Instructions: Please place a cross on the most appropriate answer for the ones given below.

Name of Participant: _____Name of School: _____

A BIOGRAPHIC INFORMATION

1. Qualification

M+3	M+4	Honour's degree	Master's degree	PhD

2. Age:

20 – 34	35-44	45-54	>55

3. Phase specialisation

ECD	Intermediate Senior	Senior FET	FET

4. Number of years teaching

0-5	6-10	11-20	≥ 21

5. Quintile Ranking of your school

Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5

6. What is your school enrolment?

Yes	No

7. Does your school have accessible internet for teaching Coding

Yes	No

8. Do you have a computer lab at school to teach C&R?

Yes	No

9. Does your school have accessible internet for teaching C&R?

Yes	No

10. Do you have any C&R background/knowledge/qualification/training?

Yes	No

11. Your school requires the following, as per the CAPS Document, as resources to implement the C&R curriculum at school. Please state if your school has the following:

	Resource	**Yes**	**No**
1	Physical coding and play activities		
2	Tangible coding with objects and verbal instructions		
3	Coding cards or symbols		
4	Simple character instructions		
5	Simple visual code symbols and constructs (tangible or on paper)		
6	Written instructions – code symbols		

APPENDIX G -Interview Schedule for Participants

One-on-one interviews

1.) Research Question One: What are teachers' current experiences of the implementation and diffusion of C&R curriculum in primary schools?

a) How do you feel about the implementation and diffusion of C&R curriculum in primary schools?

b) Has your school begun C&R teaching?

c) What challenges have you faced in implementing the C&R curriculum in your classroom or in your school?

d) Okay, how well prepared do you feel to teach this curriculum, this new curriculum?

e) What kind of training or resources have you received to support the implementation of C&R?

f) Was the training useful? Why or why not

i) What type of training or support would make teaching C&R easier for you?

g) Do **y**ou think the implementation of C&R is consistent across schools?

Question 2. Why should non-digital pedagogical approaches (unplugged) be adapted to teach the C&R curriculum?

a) Have you attended any workshop/training that introduced you to non-digital pedagogical approaches (unplugged) to teaching the C&R curriculum? Who organised that workshop/training/? Was it useful? In what ways?

b) Interviewer: Have you used unplugged non-digital approaches to teach C&R? If yes, what challenges did you experience?

c) What is your understanding of the value of unplugged approaches in this context?

APPENDIX H- Collage Design

Create a collage from magazines, newspapers or internet pictures to represent your views about C&R.

RQ:

- *How do teachers view C&R in the classroom?*

Prompts:

- What are your views on your role in the teaching of the C&R subject in the classroom?
- What are your views on the benefits/challenges of teaching C&R in your classroom?
- How do you negotiate your beliefs on technology and your teaching of C&R?
- What are your experiences of implementing C&R at your school?
- How do you navigate through challenges you experience when implementing C&R?
- What support, if any, do you believe you require from the Department of Education that will further equip you on dealing with the challenges that prevent you from properly implementing C&R at schools?
- What best practices have you discovered while teaching C&R in your particular classroom?
- Express the different teaching techniques you use to teach C&R in your class?
- What new strategies have you discovered that you can share as best practices with other educators to diffuse C&R at schools?

Appendix I: Phase 5 Focus Group Interview Schedules

Five Focus Group Interviews — Post-Workshop Feedback Sessions

Participants	PFG-1 through PFG-10 (ten Foundation Phase teachers from Quintiles 2–5, Pinetown District)
Duration	45–60 minutes per session
Format	Semi-structured, group discussion with probing questions
Facilitated by	The researcher (who also facilitated the workshops)
Recording	Audio-recorded and transcribed verbatim using Otter.ai
Workshop focus	Applying computational thinking to develop a set of logical instructions to solve a problem
Activity	Find the shortest route for the Uber delivery person (Adapted from CAPS C&R, Foundation Phase, p. 15)

Focus Group Interview One

Following Workshop One: Introduction to C&R Unplugged
Activity: Finding the shortest route — problem-based learning using algorithms
Interview Schedule — Focus Group One

The following semi-structured questions were used to guide the focus group discussion after Workshop One. Participants were encouraged to respond freely and to build on one another's contributions.

> **Q1:** What was your first reaction when you were told that today's workshop would not use any computers or digital devices?

> **Q2:** How did the activity of finding the shortest route help you understand what computational thinking actually means in practice?

> **Q3:** The C&R CAPS document allocates one hour per week to the subject, taken from Life Skills. After doing today's activity, do you feel this allocation is sufficient?

> **Q4:** Was there any part of the activity that you found difficult, and if so, how did you work through it?

> **Q5:** How do you think your learners in your specific school context will respond to an activity like this?

> **Q6:** Has today's workshop changed how you think about your own ability to teach C&R? If so, in what way?

Focus Group Interview Two

Following Workshop Two: Algorithms and Coding — Part A

Activity: Leveraging limited resources to design a robot

Workshop focus	Using limited, everyday school resources to design and build a functional model of a robot
Activity	Participants designed a cardboard robot using only materials found at their schools (Adapted from CAPS C&R, Foundation Phase, p. 28)

The following semi-structured questions were used to guide the focus group discussion after Workshop Two.

> **Q1:** During the activity, you were asked to use only materials that would be available at your school. What materials did you choose, and why?

> **Q2:** What was the most significant challenge you faced during the design activity, and how did your group address it?

> **Q3:** Before this workshop, what were your main concerns about teaching C&R given the resource limitations at your school?

> **Q4:** The workshop connected today's activity to the CAPS Algorithms and Coding strand for the Foundation Phase. Did you see that connection? Explain.

> **Q5:** How has this activity shifted your thinking about what 'good teaching' of C&R looks like?

> **Q6:** What will you do differently in your classroom based on what you learned today?

Focus Group Interview Three

Following Workshop Three: Algorithms and Coding — Part B

Activity: Continuing to leverage limited resources — refining and extending the robot design

Workshop focus	Building on Workshop Two — participants refined their robot designs and introduced basic input/output concepts
Activity	Extending the cardboard robot: adding movement, sequencing instructions, and testing the algorithm (Adapted from CAPS C&R, Foundation Phase, p. 28)

Interview Schedule — Focus Group Three

The following semi-structured questions were used to guide the discussion after Workshop Three, which built directly on the activities of Workshop Two.

> **Q1:** Workshop Three continued from where Workshop Two ended. How did it feel to return to your robot design and make improvements?

> **Q2:** Today you introduced the idea of giving your robot a sequence of instructions — an algorithm. How would you explain the concept of an algorithm to a Grade One or Grade Two learner?

> **Q3:** One of the themes that came up in the pre-workshop interviews was that many of you felt the DBE's initial C&R training was too fast-paced and full of jargon. How does today's workshop compare to that experience?

> **Q4:** How did working collaboratively with other teachers across different quintiles affect your learning today?

> **Q5:** At this point in the workshop series, how has your confidence in teaching C&R changed compared to before the workshops began?

Focus Group Interview Four

Following Workshop Four: Problem-Solving — Caryn the Crane Driver

Activity: Simulating robot operations using everyday classroom objects

Workshop focus	Sequential problem-solving — determining the correct set of instructions to swap the positions of two crates
Activity	Participants used bottles and paper labelled A and B to physically re-enact the crane instructions (Adapted from Tangible Africa: Unplugged Activities by the Leva Foundation)

Interview Schedule — Focus Group Four

The following semi-structured questions guided the discussion after Workshop Four, which focused on the problem-solving strand of the C&R CAPS curriculum.

> **Q1:** In today's activity you used your hands and physical objects to play the role of the crane. What did this physical enactment teach you that a written explanation could not?

> **Q2:** The activity involved six commands: left, right, up, down, grab, and release. How does this connect to the programming concepts your learners need to develop?

> **Q3:** Was there any moment during the activity when you or your group got it wrong? If so, how did you handle that, and what did it teach you?

> **Q4:** This workshop was designed around a context — Caryn the Crane Driver — rather than an abstract coding exercise. How important is real-world context in teaching C&R to Foundation Phase learners?

> **Q5:** How would you adapt the Caryn the Crane Driver activity for your own classroom? What changes would you make to suit your learners and your resources?

> **Q6:** We are now four workshops into this series. Looking back at where you started, what is the most significant change you have noticed in yourself as a teacher of C&R?

Focus Group Interview Five

Following Workshop Five: Outdoor C&R Activity — The Short and the Tall of It

Activity: Recognising and interpreting patterns in symbolic data sets — conducted outdoors

Workshop focus	Pattern recognition and problem-solving through physical outdoor participation — participants became the 'data' in the activity
Activity	'The Short and the Tall of It' — using height and positional data to solve a sequencing problem, enacted in the school grounds (Adapted from Tangible Africa: Unplugged Activities by the Leva Foundation)

Interview Schedule — Focus Group Five

The following semi-structured questions guided the discussion after Workshop Five — the final workshop in the series. This session took place outdoors as an extension of the activity itself.

> **Q1:** This was the first time in the workshop series that we moved outside. What was your immediate reaction to conducting a coding activity in the school grounds?

> **Q2:** In today's activity, you became the data — you were the children in the problem, standing in a line, counting how many people were taller than you. How did embodying the problem help you understand the concept of pattern recognition?

> **Q3:** One of the concerns raised in the pre-workshop interviews was that excessive screen time is contributing to a 'nature deficit' in learners — a loss of connection with the natural environment. How does today's outdoor activity speak to that concern?

> **Q4:** Looking back at all five workshops, which activity do you think will have the greatest impact on your teaching practice, and why?

> **Q5:** The workshops were built around the principle that the C&R curriculum can be adapted to meet the specific needs and resources of individual schools. Do you now feel equipped to make those adaptations independently, without the researcher's guidance?

> **Q6:** If you were to advise the Department of Basic Education on how to improve the professional development programme for C&R, what would your main recommendation be?

APPENDIX J- Questionnaire: 3 months after the Coding and Robotics Workshops

Thank you for participating in our coding and robotics workshops. We value your feedback and reflections on the experience. Please answer the questions honestly, and feel free to elaborate on your responses.

1. What were your expectations from the coding and robotics workshops, and were they met?

_____

_____

_____

2. Which aspects of the workshops did you find most engaging and informative?

_____

_____

_____

Section 2: Implementation in Schools

1. Have you been able to implement coding and robotics in your school using the tools and skills learned during the workshops?

_____

2. If not, what challenges or barriers have prevented you from implementing coding and robotics in your school?

_____

_____

_____

Section 3: Challenges and Support

1. What kind of support or resources do you need to effectively teach coding and robotics in your school?

_____

_____

_____

2. Do you need training on how to adapt curriculum materials for learners with diverse abilities and needs.

_____

_____

_____

Section 4: Suggestions for Improvement

1. What suggestions do you have for improving the coding and robotics curriculum to better meet the needs of schools?

_____

_____

_____

Conclusion:

Thank you for taking the time to reflect on your experience with our coding and robotics workshops.

TANYA-LEE STEWART LANGUAGE PRACTITIONER

EDITING CERTIFICATE

11 November 2025

To whom it may concern

DECLARATION OF LANGUAGE EDITING

Re: Teachers' Experiences of the Implementation and Teaching of the Coding and Robotics Curriculum in Primary Schools.

(Thesis submitted to the School of Education, University of KwaZulu-Natal in the Discipline of Educational Leadership, Management and Policy in fulfilment of the academic requirements for the degree, Doctor of Philosophy)

This serves to confirm that I, Tanya-Lee R Stewart, a SATI-registered language editor and translator, undertook the language editing of the above-mentioned document on behalf of P Chunder (student number: 204004663).

Do note that I make no claims to the substantive matter covered by the document and have not altered the intent or research content drafted by the author(s). Furthermore, I can only provide a guarantee of linguistic accuracy, provided the relevant track changes were accepted and my advice followed. All changes and corrections were suggested by means of “track changes”, comments, and emails. However, the implementation thereof was left entirely up to the author.

As such, I do not accept responsibility or liability for any inaccuracies, both linguistically and content-related, that may be present. In addition, it is assumed that the student has been advised to refrain from any form of plagiarism.

Should you have any queries, please contact me through the email address and telephone number provided in the above letterhead. Yours sincerely

[redacted]

TR Stewart

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