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Teaching coding and robotics in rural schools

By

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A dissertation submitted in fulfilment of the requirements for the
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Abstract

Coding and robotics are exciting fields that combine programming, engineering, and innovation. Studying coding and robotics can be a fantastic way to develop valuable skills and open up exciting career opportunities. However, for rural schools, it is often accompanied with inadequate teaching resources. South Africa has introduced coding and robotics into its school curriculum. This move is expected to modernise the education system, focusing on developing 21st century skills like problem-solving, critical thinking, and creativity. This study focuses on teaching coding and robotics in rural schools

Unlike the traditional subjects like history and geography, on foundation phase (Grades R-3) coding and robotics curriculum focuses on unplugged coding activities, pattern recognition, and basic robotics concepts. Intermediate phase (Grades 4-6) develops programming skills using block-based coding platforms and introduces more complex robotics concepts. Senior phase (Grades 7-9) builds on previous knowledge, emphasising advanced programming concepts, robotics, and application skills.

This study adopted an integration of Cognitive Load Theory (CLT) and social constructivism. Qualitative methods were supported as it is in accordance with the interpretivism paradigm. All data collection took place through questionnaires, workshops and observations and semi-structured interview. The sample size was 16 participants from all four schools (four teachers from each school).

The results show that teachers are not teaching coding and robotics in their school due to limited technological resources and inadequate teacher training. Schools lack necessary infrastructure such as computer labs and internet connectivity. Teachers need professional development to effectively teach coding and robotics. Developing effective assessment methods for coding and robotics can be difficult. Effortlessly integrating coding and robotics into existing curricula can be complex.

Furthermore, addressing these challenges requires collaboration between teachers, policymakers and stakeholders to provide support and resources. In addition, strategic alliances between organisations and government are important for providing resources and support. The researcher proposes that the rural schools should be introducing unplugged coding, since it is teaching coding without using digital devices. It is accessible without access to technology.

Keywords: Coding, Teaching, Robotics, rural schools and 21st century

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Dedication

I dedicate this work with love and gratitude to my late mother Nowethu Sylvia and my missing father Khangelani Goqweni, my three beautiful children; Likamva Junior, Linam and Linawo and my entire family. Life was not the easy journey, my children you were the pillar of my strength in this journey as I faced many challenges. To my sibling and extended family, your support and encouragement meant so much to me. Thank you for being part of my learning journey.

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Declaration

I Goqweni Zimbini declare that

- (i) The research reported in this dissertation, except where otherwise indicated, and is my original work.
- (ii) This dissertation has not been submitted for any degree or examination at any other university. (iii) This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
- (iv) This dissertation does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
 - a) Their words have been re-written but the general information attributed to them has been referenced;
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Goqweni Zimbini 221090189

AI Declaration

a) I made use of generative AI in this dissertation in the following areas: qualitative data analysis, to draft summaries for data analysis and discussions. Citations were added to statements where applicable, to assign credit to authors.

Signed:



Goqweni Zimbini



List of Abbreviations

ANNSSF: Amended National Norms and Standards for School Funding

CT: Computation thinking

CTL: Cognitive load theory

ECE: Early childhood education

ER: Educational robotics

ICT: Information and communication technology

IT: Information technology

STEM: Technology, Engineering, and Mathematics

DBE: Department of Basic Education

FET: Further Education and Training

SAT1: School A Teacher 1

SBT1: School B Teacher 1

SCT1: School C Teacher 1

SDT1: School D Teacher 1

OUPSA: Oxford University Press Southern Africa

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

The Department of Basic Education (2021) states that “coding and robotics subject is central to function in a digital and information-driven world; apply digital ICT skills and transfer these skills to solve everyday problems in the development of learners” (p.12). By introducing coding and robotics, learners can be empowered with essential skills, creativity, and problem-solving abilities, setting them up for success in an increasingly complex, technology-driven world. Robotics has existed in education since the late 1980s, but they have only gained so much consideration from teachers in recent years, due to many challenges (Evripidou et al., 2020). In South Africa, implementing coding and robotics education presents limited online educational content, low literacy rates, restricted connectivity in rural regions, and a lack of teacher training and investment in emerging technology (Caps 123, 2023).

1.2 Background

Former South African Minister of Basic Education, Angie Motshekga, addressed this shortcoming in 2020 by confirming that a new coding and robotics subject will be introduced to schools by 2023 (Business Tech, 2020). The subject will be incorporated into the grades R to nine curriculum, with great care taken to ensure continuous progression from one phase to the next. The draft curriculum was drawn up and submitted to Umalusi, the Council for Quality Assurance in General and Further Education and Training, for evaluation. President Cyril Ramaphosa announced in February 2021 that the Department of Basic Education would launch a pilot program that year. This programme was designed to be implemented to test the draft curriculum, so as to allow possible amendments to be made before all public schools in the country present the material. The curriculum from grades R to Three was planned to be piloted in 200 schools across the country, while the Grade Seven material was to be introduced to 1000 schools (Khoza, 2021).

According to Business Tech (2022), the pilot curriculum was confirmed to be introduced to some schools in the third term of 2021. The pilot programme for grades Four to Six and Grade Eight was planned for 2022, and the Grade Nine pilot for 2023. The full implementation of the Coding and Robotics subject was planned for grades R to Three and Seven in 2023, with grades Four to Six and Grade Eight planned for 2024 and the Grade Nine full implementation for 2025 (Business Tech, 2022; Khumalo, 2022). There have been no further notices on the progress of

the pilot programme for the coding and robotics curriculum. The DBE did, however, confirm that a team of people were to be trained in March 2021 concerning the teaching of the subject. According to Lang (2021), this team was then to train the respective teachers to present the subject in the pilot rollout, but it is unclear as to the extent to which these plans have materialised.

The teaching of coding and robotics in schools has gained immense momentum internationally, Qatar, the oil-rich nation that is making an effort to prepare its young generation for the technological revolution that will shape future jobs, is restructuring its education system to include coding (Boboskey, 2022). According to the South African Department of Basic Education (DBE, 2022), coding and robotics are critical for students' development in order to function in a digital and information-driven world, apply digital ICT skills, and transfer these skills to solve everyday problems.

The study by Güleriyüz et al. (2021) states that "in Japan, the government made programming courses mandatory at schools for the development of student's creative abilities" (p.39). The Japanese government were aware of the importance of coding and robotics education and made it compulsory in primary schools in 2020, secondary schools in 2021 and high schools in 2022. They made a point that at all levels of education, this curriculum is introduced, where, as for South Africa, focus remains at primary level.

Güleriyüz and Dilber (2021) emphasised that "coding and robotics have an important place in the education of students who are equipped with 21st century skills, able to solve problems they face, and able to use technology effectively, capable of creating products" (p.39). This subject allows learners to be able to build problem-solving skills, encourages creativity and prepares learners for tech careers. Up skilling learners in tech careers can enhance job creation and innovation.

Moloi and Mhlana (2021) claim that South African rural-based higher education institutions (HEIs) encounter challenges, including poor reading and literacy skills, poor reasoning and logic skills, and inadequate use of technology assets. A rural school is defined as a public school located in a rural area (Majorie & Karen, 2020). On the other hand, non-rural schools are urban schools with proper infrastructure like running water from taps, proper sanitation,

and closer to cities. Rural schools often face unique challenges when providing educational opportunities for their students, due to limited resources or teaching infrastructure.

In addition, the research will be based on schools that are classified under Quintile 1, which are poor schools. The Amended National Norms and Standards for School Funding (ANNSSF) required the ranking of schools into one of five quintiles, of which Quintile 1 represents the poorest schools and Quintile 5 the most affluent (Van Dyk & White, 2019). A school at Quintile level 2 has limited resources, where the learners are provided with a meal a day by the nutrition programme, and the funding received (norms and standards) typically reflects the high unemployment, low-income and social-economic status, and low level of education in the surrounding community in which it is situated (van Dyk & White, 2019).

In South Africa, there is a lack of early exposure to the fundamentals of coding and robotics. Some schools have not yet introduced coding and robotics to their schools. These schools lack basic infrastructure that is needed to provide quality teaching. Also, other school subjects, such as physical sciences, economics and history, there are subjects in the prior phases that lay the foundation for these subjects in the Further Education Training (FET) phase (Govender et al., 2021). This research hopes to motivate many rural schools not to become dejected when introducing coding and robotics, but to find innovative ways to achieve the intended subject content.

Programming and robotics are present in school curricula in several countries. However, some of these face challenges in implementing these initiatives, due to a lack of computers and the high cost of educational robotics kits (Gabriel et al., 2021). According to Greyling (2023) unplugged coding is explained as the collection of learning activities that introduce coding and programming through engaging games. Rural schools can execute unplugged coding, since coding activities may not require a computer or a digital device.

I became interested in teaching coding and robotics after noticing the gap between various primary schools in my district. Some of the teachers in these schools always complained about this new curriculum, saying that they did not know what needed to be done. Their complaints attracted me to research teaching robotics and coding in rural schools. The teaching and learning of coding and robotics is still given less attention, due to challenges, such as teachers' lack of knowledge and skills. Some teachers are unmotivated, due to preconceptions about their difficulties, which hinder their learning and subsequent application in the classroom

(OrtegaRuipérez & Lázaro Alcalde, 2022). The teachers showed that they need professional development and consistent support regarding this subject. Workshops are limited to teachers' understanding of the dissemination of the new curriculum, where rural schools claim that they are still waiting for the teaching material to be distributed to their schools.

According to Sisman and Kucuk (2019), “teachers need to use this instrument in teaching the science of robotics as well as in helping students master the subject and gain experience” (p.50). According to Mubin et al., 2013 “one of the major shortcomings in the area is the absence of well-defined curriculum and learning material for teachers” (p.5). This means that robotics education is still seen as an extra-curricular activity, and a part of informal education, as many schools have not introduced it. Also, teachers need to be relieved that the target is not to replace them with robots, but rather provide them with a teaching tool/aid that can ensure the learning experience and motivation of the learners. Teachers in this district complain that the training is very limited; therefore, adequate time ought to be given to educate teachers.

This research will highlight the various experiences that teachers get in teaching coding and robotics in rural schools. I believe that greater effort should be devoted not only to the development of coding and robotics curriculum, learning and teaching materials should be accessible (Mubin et al., 2013). Caps 123, 2023 supports that coding and robotics improves logical thinking and problem-solving skills, enhancing creativity and innovation, preparing students for future careers, encouraging collaborative learning, making learning fun and engaging, and empowering teachers to become effective educators in the 21st century.

1.3 Purpose of the study

This research serves to determine the experiences and factors that influence the teaching of coding and robotics in rural schools. Seckin-Kapucu (2023) indicates that “the 21st century have access to vast amounts of information and live in a technology- and media-driven environment” (p.74). It is of great importance for teachers to adjust to the needs of this century. This research also intends to motivate the teachers to use the equipment and to motivate their learners to use these tools. To increase the positive attitude of teachers in conducting their lessons using coding and robotics.

1.4 Significance of the study

Coding and robotics are crucial in today's technology-driven world, offering several benefits and opportunities. It is essential for bridging the digital divide and preparing students for a technology-driven future. Introducing coding and robotics in rural schools can help bridge the skill gap in technology-related fields, meeting market demand for skilled workers. By understanding coding and robotics, individuals can unlock new opportunities, drive innovation, and shape the future. Coding and robotics education prepares learners for in-demand jobs and careers in technology, driving economic growth and development. Integrating coding into the curriculum helps learners become digitally literate, which is a vital skill in today's world.

This study will help to improve the teaching of this subject. By examining the unique challenges and opportunities faced by teachers, the policy makers and curriculum developers will be informed about various concerns of coding and robotics in rural schools. Furthermore, executing of this subject will ensure that learners are equipped with relevant 21st century skills. By addressing the use of non-digital mediums, the research also contributes to innovative instructional strategies that can bridge the digital divide, ensuring equitable access to quality education for learners in rural communities.

1.5 Research objectives

Objective 1: To explore the unique challenges and opportunities faced by teachers in rural schools when implementing coding and robotics.

Objective2: To examine the impact of teaching coding and robotics in rural schools.

Objective3: To identify strategies and challenges involved in teaching coding and robotics through non-digital mediums in rural schools.

1.6 Research questions

1. What are the experiences faced by teachers in rural school teaching coding and robotics?

Allows the researcher to identify any uniqueness and how do these teacher experiences influence the pedagogical practices.

2. How does teaching coding and robotics impact rural schools?

Allow the researcher to examine the effects on student learning outcomes, engagement, and interest in coding and robotics.

3. What are the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools?

Allow the researcher to understand what the implications for curriculum design and instructional method are.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This literature review aims to explore the teaching of coding and robotics in rural schools. This chapter presents the information that scholars have regarding the teaching of coding and robotics in rural schools. Coding and robotics are being integrated into educational systems worldwide, where many countries recognise their importance for future skills and innovation. Various countries aim to equip learners with essential skills for the 21st century. This chapter outlines the analysis of existing research on coding and robotics in schools. Additionally, this provides background information and situates coding and robotics within the existing knowledge.

2.2 International consideration

Many countries have implemented educational policies to incorporate digital technologies into rural education so as to fulfil constitutional rights and international obligations to ensure that all students have equal access to learning and development opportunities. A viable way to incorporate the knowledge and use of technology in the classroom is through educational robotics. Robotics is interdisciplinary, and promotes the development of many 21st-century skills. According to Ogegbo and Aina (2024) coding and robotics as a subject involve activities that involve problem-solving through logical and computational thinking. Robotics has stimulated the development of various proposals seeking to incorporate it as a regular part of mathematics and science curricula, such that all students can benefit from them (Castro et al., 2023).

A study about the design and application of educational robotics projects in Latin American and Caribbean countries was reported, where their absence was noted. The main challenges are mainly based on the development of guided constructions; a lack of standardisation of the teaching at a national level facilitating the improvement on programming abilities; and the lack of educational facilities at higher education levels, as well as training programmes for teachers (Díaz-Lauzurica et al., 2019).

The Philippines has introduced coding as a subject in primary and secondary schools, although the government is not overly committed to the project, as it spends little on coding education compared with Malaysia, Thailand, Vietnam, and Indonesia, the pupils show a great deal of interest in coding, and are willing to learn coding in school. Apart from schools, there are other places in the Philippines where kids are taught how to code. One of the places that started in the Philippines in an effort to educate children on how to code, Kaya Coding is one of the pioneer initiatives that educate children on how to code (Boboskey, 2022).

Many countries are seeking ways to help their students to develop appropriate skills and to gain the right knowledge in order to design and develop scientific literacy, technology, and innovation that can strengthen their nation's place within the global economy. To achieve this goal, it is important to first create a desire in students to study in the STEM field, since people well-trained in STEM areas can more effectively enhance the development of technology. STEM education (Science, Technology, Engineering, and Mathematics) proves to be a central element in supporting the process of digital transformation, as the knowledge and skills acquired in these fields form the foundation for innovative decision-making and technological progress (Bitsadze, et al., 2025).

Countries like Finland, China, Singapore and United State emphasised the importance of incorporating coding and robotics (Wu, 2020). Recently, STEM education has started to become more integrated into the traditional educational settings with the aim being to attract an increasing number of students to STEM-related courses and projects, and thereby to motivate them to choose a career within the STEM field in order to fulfil the demand for tomorrow's workforce (Erol, 2023).

2.3 Coding and Robotics in South Africa

The Coding and Robotics subject is aimed at guiding and preparing learners to solve problems, think critically, work collaboratively and creatively, and function in a digital and information driven world, applying digital and ICT skills, in order to transfer these skills to solve everyday problems and determine novel possibilities (DoE, 2019). South Africa is in the midst of the Fourth Industrial Revolution (4IR), and as a result, the South African Government established vision 2030, which has been set up to gear and prepare young people for jobs and skills of the future (Govender & Govender, 2021).

The DoE has indicated that the coding and robotics subject is central to function in a digital and information-driven world and transfer skills to young learners in order to resolve daily problem that learners face (Prinsloo, 2024). This subject focuses on activities that deal with the solution of problems through logical and computation thinking. Coding is possible with computers and without computers, Prinsloo (2024) supports that it is important for children to learn to code without computers. He further argues that taking into consideration the aim of coding and robotics curriculum and current research on how learning taking place in the early years.

South Africa has introduced coding and robotics into its basic education curriculum as a strategic measure to enhance future economic competitiveness (Magoqa, 2025). This move will modernise the South African school curriculum and bring about a much-needed focus to the development of 21st century skills. While the focus of the curriculum especially in the Foundation Phase is on unplugged coding, many have expressed concern about those schools that do not have computer laboratories or high-speed Wi-Fi connections for their learners from Grades Four to Nine. Learners are able to get the skills that they too need to unlock access to the digital world that seems certain to be their future (Oxford University Press., 2024).

Introducing digital technological skills and coding into education is not just a recommendation, but instead a requirement established by the European Union, with which educational institutions in the EU ought to comply (Schina, et al., 2021). Robotics and coding education aims to teach students the basic principles of robots and coding language to enable students to establish close relationships with technology and become independent individuals. Through robotics and coding education, students find opportunities to develop problem solving, computational thinking, creative thinking, and language skills.

The DBE has developed a coding and robotics curriculum for Grades R to Grade Nine, which is being piloted in more than 1000 schools across the country. SASOL has provided training to 200 teachers and subject advisors from nine provinces trained on 4IR, and 200 primary schools in Grades R, Three and Seven are supported with coding and robotics. The DBE has officially announced the addition of Coding and Robotics to the school curricula in South Africa (Oxford University Press, 2024).

Many countries have implemented educational policies to incorporate digital technologies into rural education to fulfil constitutional rights and international obligations to ensure that all

students have equal access to learning and development opportunities. Despite these efforts, students in multigrade classrooms in these areas often struggle to meet learning standards in subjects such as language, mathematics, and science, as well as in developing digital skills. As a result, it is necessary to explore new strategies to address these inequalities and improve student learning outcomes in multigrade classrooms in rural areas. A viable way to incorporate the knowledge and use of technology in the classroom is through educational robotics. Robotics is interdisciplinary and promotes the development of many 21st-century skills. Robotics has stimulated the development of various proposals, seeking to incorporate this as a regular part of mathematics and science curricula so that all students can benefit from them (Castro et al., 2023).

2.4 Difficulties arise in most primary schools

In the absence of proper training of coding and robotics or insufficient teaching electronics, teachers will be reluctant to introduce this subject. Certain studies shows that challenges arise in most primary school either at the technical level of caused by teachers who lack relevant knowledge or lack relevant provision for their effective integration into primary school curricular (Tzagkaraki et al., 2021). If teachers lack knowledge about the subject, there will be no productivity, and learners will be left behind. Difficulties that hinder proper learning process needs to be addressed, as they prevail so as to ensure equality in education.

Govindarajan (2022) has argued that, even if teachers have the appropriate knowledge and skills, feel confident in their abilities to integrate technology, and have strong academic beliefs around technology usage, the context in which teachers work may still constrain or limit their individual efforts. Teachers who are reluctant to use technology and have little experience and knowledge might be confronted with outside pressures to introduce coding and robotics in classrooms. Teachers should therefore not be reluctant to use technology, in response to the demands of the century.

Primary schools with no electronic facilities or limited facilities are encouraged to adopt an unplugged coding approach. Teacher should be motivated to attend training session and workshops organised to train them. All learner should be motivated to code, even if they are from deep rural areas. In other cases, schools with limited electronic resources ought to be encouraged to teach learners in groups and promote the spirit of sharing. To overcome the

above challenges, both novice and experienced teacher training is required so as to encourage learning that leads to technological literacy on the basis of the current society's demands (Gorrah, 2022).

2.5 Rural challenges

Rural village communities have the primary characteristic that they are low-resourced, resource-poor communities of very resource challenged. Examples of these scarce resources pertain to modern technologies and include power, energy, internet, smartphones, and digital platforms. One of the most important factors contributing to education differences in urban and rural areas is the accessibility of resources (Wood, 2023). Rural areas often lack these resources, making it difficult for learners in these areas to access excellent education. Educational projects can be started in the rural villages, typically using donations and largess of others, although reliance on donations from outside the local community, including members of their own diaspora, will be sporadic and therefore not sustainable (Amenyo & Kpo, 2023).

Lack of access to infrastructure is a significant barrier to education in rural areas. For instance, schools in rural areas may not have reliable electricity, making it challenging to use technology to enhance the quality of education. Moreover, poor road infrastructure makes it difficult for teachers to travel to remote areas, and students may have to walk long distances to get to school. There are still communities where learners do not go to school if there are heavy rains, because basic infrastructure like bridges and roads are not in good conditions.

Learners in rural areas often face challenges in accessing quality education, leading to lower levels of academic achievement and a lack of opportunities for personal development. This, in turn, affects their future prospects for employment and career advancement. Learners will find it difficult to compete with learners from well-resourced urban schools. Investing in infrastructure such as roads, electricity, and internet connectivity is essential for bridging the education gap between urban and rural areas. The South African Schools Act (1996) is clear that, through school stakeholders such as School Governing Bodies (SGBs), schools are required to supplement resources provided by the State (Mkhize & Davids, 2023). Most of the schools in rural areas find it difficult to supplement their resources, since there is a high rate of poverty, and many people depend on social grants.

Rural children live in poverty, which unfortunately and unavoidably, impacts their preparedness for academic performance. The only minimal assumptions to be made in the development and execution of the project is that they are kids by age; they are growing up in low-resourced or limited-resource environments and their learning deficits and deficiencies can be addressed using digital assistants. (Amenyo & Kpo, 2023). In order to ensure that education differences do not occur in urban and rural areas, it is essential to implement comprehensive strategies that address the root causes of the problem. Equal educational opportunities ought to be offered to all learners.

2.6 Insufficient teaching resources

The lack of knowledge, resources, and official assistance, many teachers feel uncertainty, anxiety, or even fear regarding digital media use in daily teaching practice. Indeed, educators face various difficulties in their efforts to include educational robotics (ER) in their daily teaching practice, which results in the weak presence of ER in the classroom. Greyling (2023) highlighted that one of the biggest challenges for rolling this out in the country is the fact that we have nearly 16000 schools without any computer labs. Challenges included insufficient appropriate learning materials, a lack of extensive learning activities, tasks and limited opportunities to engage learners (Yuqin et al., 2020).

The findings indicate that teachers are aware of the importance of digital skills, but their ability to put that knowledge into practice is hindered by a lack of resources (Mhlongo, 2025). Teachers justified this by noting that their schools lacked the financial resources to buy coding and robotics hardware and technology equipment, such as tablets. It is suggested that schools ought to have physical and technological equipment in order to teach such applications to learners in a learning environment across many classes and learners should have access to a coding and robotics (Gorrah, 2022).

In addition, Caps 123 (2023) also outlines that some schools have the latest technology and facilities others lack even basic computer equipment, making it difficult to implement coding and robotics programmes. Appropriate teaching resources should be made available to all schools. Unavailable teaching resources result in the poor implementation of robotics and coding. This new curriculum is demanding therefore appropriate measures to ensure success should be applied. The quintile 1 and 2 schools have fewer resources both in terms of funding and personnel. Most of the learners come from a poor background. There is still a big gap

between rural and urban schools, where most urban schools are equipped with the most recent infrastructure (Van Dyk & White, 2019).

A further challenge for South Africa is that software development is seen as one of the scarcest skills. Software development remains one of the highest sought-after skills, with information (Greyling, 2023). In South Africa there is a problem with this as the poorer and more disadvantaged communities lack access to computers. These schools will bear the cost of setting up and maintaining computer labs, resulting in a lack of computing infrastructure in many schools. Frequent power cuts do not allow for the efficient operation of computer labs and computers. School teachers are not equipped to teach coding, and are also overwhelmed by curriculum demand, where proper teacher development is sorely needed.

2.7 Teacher development

Providing teachers with specialised training programmes in ER could contribute to ER technologies being introduced into the teaching and learning process. Moreover, student teachers' responses to educational robotics, such as their perceptions and self-efficacy, could be used to enrich current ER training initiatives (Schina, 2021). Effective training in technology integration focuses on content that enables teachers to know exactly what is expected from them in the classroom. Teachers need to receive training about coding and robotics so as to ensure that they can integrate technology into teaching learners.

In the South African context, a lack of research exists regarding the readiness of educators to teach student teachers robotic and coding skills (De Jager, 2023). Educators need effective training to change their teaching and learning methodology and integrate technology skills when teaching. Studies conducted on educator training globally have revealed that most educators have not been effectively trained to teach coding and robotics (De Jager, 2023). Teachers have to design, and reflect upon the teaching learning process, not only from the perspective of the teacher, but also from the point of view of the learners, so as to satisfy their inquisitiveness for knowledge. For teachers to effectively teach this subject, in-depth training and support is needed.

Countries that want to transform effectively ought to train qualified personnel for coding and robotics. Individuals are expected to have the skills needed by this age. Although these skills have been valued since prehistoric times, the complexity of modern production and management processes makes them even more crucial. Skills such as critical thinking, problem

solving, flexible thinking, media literacy, algorithmic thinking, and coding are considered 21st century or new millennium skills. To gain these skills, education stakeholders implement practices and training at different levels, from university to high school and preschool. Basic information literacy, robotics, programming and coding are but some of these skills. In addition to the formal training offered in educational institutions, informal training, competitions, and activities provided by various government and other organisations and institutions are also striking.

Eteokleous (2021) states that “the field of robotics in a classroom context has seen an increase in global momentum recently because of its positive contributions in the teaching of science, technology, engineering, mathematics (STEM) and beyond” (p.368). It is argued that when robotics and programming are integrated in developmentally appropriate ways, cognitive skill development beyond STEM can be achieved. The development of educational robotics has presented a plethora of ways in which students can be assisted in the classroom. *Designing, Constructing, and Programming Robots for Learning* highlights the importance of integrating robotics in educational practice and presents various ways for how it can be achieved (Eteokleous, 2021).

Workshops that are meant to educate teachers about teaching robotics and coding are limited (Boz and Alleksaht-Snider, 2022). Studies that assess educational robotics (ER) perception are often undertaken within the context of voluntary workshops and professional development programs that suffer from a lack of generalisability (Hamamsy et al., 2021). Restrictions on ER professional development include the fact that training courses for teachers are not a common practice and reports of such irregular activities are often unsatisfying. Boz and Alleksaht-Snider, 2022 support at the beginning of the workshop, the teachers were resistant to the idea that coding integration could benefit learning.

In addition, training leads to increased self-efficacy for teachers and a higher possibility of adopting technology into their daily teaching and learning practices. According to Papadakis et al. (2021) the teacher needs to provide the necessary resources and support to boost student engagement and maximise their potential through various projects inside an open and non-judgmental atmosphere; this results in a collaborative classroom environment that fosters creativity and knowledge creation. CAPS 123, 2023 supports that teacher training, in particular, is a focal point of this initiative. Given that educators are the primary facilitators of knowledge,

it is essential that they be equipped with the skills and knowledge to confidently impart coding and robotics concepts.

Teachers in various primary schools require more training on how to incorporate coding technologies in their instruction. For instance, even if teachers understand what algorithms are, they report needing support regarding how to teach algorithms to their students. One important way of supporting elementary teachers' knowledge around coding and robotics, and how to teach coding and robotics to students, is professional development (Govindarajan, 2022).

When the integration of robotic coding training into educational programmes is considered, it becomes obvious that robotic coding is effective in developing creativity, critical thinking, problem solving, computational thinking dimensions and language skills. Based on these findings, it is crucial for educational institutions and teachers alike to consider making robotic coding activities a part of the curriculum. Teachers can be encouraged to further develop these skills by presenting robotic projects, coding activities and problem-solving tasks in classroom environments (Okcu et al., 2023)

When it comes to the benefits of robotic coding training, robotics is understood as a technology of the future by developing day-by-day. For this reason, countries are making significant investments and incentives in this field. Countries are investing by training young children in robotic coding. Thanks to robotics education, children and young people are both prepared for the future by receiving robotics education at a young age, and their analytical skills are improved. Robotic coding contributes to the development of individuals' problem-solving, organisational and responsibility skills. Coding also teaches academic skills. With robotic coding, individuals can combine their coding and programming skills in STEM (science, technology, engineering, art, and mathematics) fields (Güleryüz & Dilber, 2022).

2.8 Teacher's attitudes

Papadakis et al. (2021 p.4) note that “previous studies have shown that, even though educators are keen on Educational robotics (ER) and appreciate its apparent added value, they tend to have a negative opinion towards using robots in schools”. Teachers can be unwilling to use robots and coding, due to negative attitudes. Many teachers may not have received coding and

robotics instruction during their teacher training programmes, leaving them feeling inadequately equipped to teach these new subjects (Mhlongo, 2025). The unwillingness of teachers to be lifelong learners can negatively impact teachers' abilities to teach robotics and coding. The study by Papadakis et al. (2021) further revealing that the percentage of in-service teachers who have strong opinions against incorporating new forms of technology in the preschool classroom has been reported to be up to 25% increasing.

The positive attitudes, coupled with a perceived need for more knowledge, shows that teachers view these subjects as essential and the demand for more knowledge in the subjects also highlights the economic benefits of these skills. Understanding teachers' perceptions and beliefs provides insights into planners, designers, and curriculum developers on what should be emphasised in STEM teacher professional development programmes and in the evaluation of existing STEM education programmes (Purmann et al., 2025).

Furthermore, most studies in the literature concluded that teacher confidence increased with increased familiarity with coding and robotics, and increased even more once teachers applied what they learned in their PL training and applied coding and robotics in their real-life classrooms (Boz and Alleksaht-Snyder, 2022). Researchers propose that it is best practice to encourage teachers to put the technical and pedagogical knowledge they have acquired under the training programme into practice (Schina et al., 2021).

To understand the complex relationships among teacher knowledge, attitudes, beliefs, and instructional behaviours, it is useful to first define these terms. Knowledge is commonly defined as information or skills acquired by a person through experience or education. For instance, one can acquire knowledge about a specific content area or even how to teach. Attitudes refer to feelings towards an object or construct and often hold judgmental value (e.g., liking or disliking something). Beliefs refer to statements that a person considers to be true, regardless of whether the statement is actually accurate. A teacher's knowledge, attitudes, and beliefs all play an important role in what the teacher does and how the teacher teaches in their classroom, which together make up the teacher's instructional behaviours or practices (Govindarajan., 2022).

2.9 Inequality

The South African education system is considered one of the most unequal in the world.

Providing learners with quality education and equipping them with the digital skills required for 4IR is essential. To achieve this, plans are in place to incorporate educational technology in schools. However, it is important to understand the factors and conditions which have had the greatest impact on this process (Hart, 2023). South African schools face numerous challenges, with class size, poor infrastructure, inadequate facilities and a lack of skilled educators being listed among the most important (Amnesty International, 2020). Equal access needs to be considered when introducing the new subject into schools.

Furthermore, a 2019 study by the World Bank found that, while some schools in South Africa have begun to introduce coding and robotics programmes, access to these opportunities is often limited to schools in urban areas. Rural areas tend to lag behind in terms of access, with many schools lacking the resources to offer these types of programmes. There are also gaps in access between different socioeconomic groups. Students from wealthier families are more likely to attend schools that offer coding and robotics programmes, giving them an advantage over their less privileged peers (Caps 123, 2023).

In South Africa schools are classified into five quintiles according to the socioeconomic status of the community in which they are located. Socioeconomic status is measured by the unemployment rate, average income and general literacy in the school's geographical area. Quintile One schools, which still mainly serve black pupils, are the poorest, and Quintile Five schools, many of them formerly white schools, are the most affluent. Quintiles One to Three are non-fee-paying schools. They receive the highest allocation pupil from the government, while quintile five schools receive the lowest. This is due to the assumption that the parents of Quintile Five school children can afford to pay school fees. Studies have shown that. Despite this attempt to distribute the funding to the benefit of less fortunate schools, inequalities persist when it comes to access to good education.

The South African context poses a unique challenge regarding the variety of public schools in the country. Vital disparities exist between schools in rural and urban areas. This might present complications in the implementation of the same material across the board. It is a challenge to

achieve the same learning outcomes in the presentation of the subject if the availability of the infrastructure varies from school to school. This reality suggests that each school needs to analyse their facilities and support before implementing the new curriculum.

2.10 Teaching and learning coding and robotics

Over the last few years, increasing attention has been focused on the development of children's acquisition of 21st-century skills and digital competencies. Consequently, many education scholars have argued that teaching technology to young children is vital in keeping up with 21st-century employment patterns. Many jobs that are available require people to be able to use technology. Technologies, such as those that involve robotics or coding apps, come at a time when the demand for computing jobs around the globe is at an all-time high, while its supply is at an all-time low. Few empirical studies that show how teachers can implement STEM programmes within the school curriculum, above all at early stages such as primary education (García-Carrillo et al., 2021).

The tools used to teach coding elements of CT skills during the early school years are, respectively: *unplugged coding*, that is, programming without the use of digital devices; educational robotics (ER), where learners give executable instructions to a programmable robot in order for it to perform specific actions in a physical environment; and *plugged coding*, which entails developing executable programmes to instruct a digital sprite to achieve a goal in a constrained digital environment. Although these tools are all used to introduce children to coding, they have different characteristics that different age groups. Plugged practices make use of computing devices, while unplugged practices do not. Unplugged coding activities involve logic games, cards, strings, or physical movements that are used to represent and understand CT concepts, such as algorithms, without requiring abstract coding (Montuori et al., 2023).

Many researchers have been investigating the coding and use of robots to support the education and learning of students. Studies have shown that robots can help students develop problem-solving skills and learn computer programming, mathematics and science. For these purposes, the use of robotic systems is becoming fundamental if applied from the earliest stage of education. The landscape of educational robotics and coding is vast, but fragmented inside and

outside school environments and situations. In the last two decades, robots have begun their incursion into the formal education system. Although several researchers have emphasised the learning potential of robotics, the slow pace of its introduction is partially justified by the cost of the kits and the different priorities of schools to access technology (Avello et al., 2020).

The benefit of teaching coding to young children is that it can easily be integrated into different subjects, such as mathematics, science, engineering, and language arts. The most common programming application for young children, such as ScratchJr, integrates coding into literacy through a story-writing–coding approach supported (Ragusa and Leung, 2023). state that robotics and coding learning tools such as Code-a-pillar, Bee-Bot, Kibo, Kubo, Makey Makey, and Scratch can be easily implemented in the classroom for robotics paired with learning to code as these opportunities are intuitive, subject-agnostic, and open-ended. Children can explore and master the basic programming functions independently or with sparse assistance. Rather than teaching coding as a separate subject in early education, these opportunities enable teachers of young children to integrate coding into the existing curriculum using their existing curricular standards. These hands-on learning opportunities encourage children to explore, discover, and experiment as they become learners, thinkers, and future innovators (Ragusa and Leung, 2023).

Educational robotics (ER) defines a broad area of knowledge-based approaches requiring students to engage in activities using simple and standard electronic components (Papadakis et al., (2021). Educational Robotics consists practical activities and represents a powerful, engaging and motivating tool for students as they design robots, operate robots and directly see the outcomes of their engagements. ER enables students to programme robots they design to suit their goals. During programming, learners build robots that interact with the environment using various sensors such as infrared, touch, colour and sound. In this way, learners develop various original robotics projects that can fulfil different functions to accomplish the goals they set. Thus, ER activities are also effective in helping students learn programming languages and improve computational skills (Kucuk & Sisman, 2020.)

2. 11 Computation Thinking (CT)

Computational thinking (CT) encompasses more than merely solving problems using concepts derived from the world of computer science (Fanchamps, et al, 2024). CT could be integrated in developmentally appropriate ways early on through robots, which provide an attractive and motivating way for children to access technology and promote CT through playful learning

(Bakala et al., 2021). There are five Computation thinking skills studied most often include Sequencing, Conditionals, Loops, Debugging, and Algorithmic Thinking (Ching & Hsu, 2024). According to Fox-Turnbull et al. (2024 p. 133) “both pedagogical content knowledge and content knowledge are needed to effectively teach computational thinking”.

The availability of tangible, physical outputs in CT activities could be beneficial to the learners as they see what they are studying about. Robotics activities support productive CT development in young learners through tangible and interactive learning. The use of a physical robot and a tangible programming environment facilitated a learning condition, in which multiple learners engaged in a collaborative process where learners actively communicated about programming decisions. Robotics activities can provide interactive and collaborative learning environments favourable for youths to learn CT.

The implementation of CT into STEM education has encountered several barriers, such as not being included in pre-service teacher courses, teachers lacking adequate backgrounds in computer science, and limited resources for integrating CT, resulting in a low sense of confidence in teaching and integrating CT in STEM education (Sunday et al., 2024). We are in living in 4IR in a technologically advanced society where learners and teachers need to be adequately prepared in order to succeed within this progressive society (Govender, 2021).

In addition, the introduction and use of programming as a vehicle to develop computational thinking in primary schools, however, calls into question the developmental readiness of young learners for an activity that involves highly abstract concepts and learning many skills at once. CT may involve different components and dimensions based on various definitions and frameworks, where this review uses CT skills as a generic term to refer to various CT dimensions (Ching & Hsu., 2024). It raises the question of how one teaches programming when learners have not developed the ability to think abstractly and logically as is required when programming. Teachers' beliefs about culturally responsive teaching, attitudes toward

computational thinking, and STEM practices, need to be flexible to different contexts (FoxTurnbull et al., 202

2.12 Robotics in STEM Education

Coding and robotics have been utilised in the teaching of several subjects, particularly scientific education, and in the teaching of various disciplines by merging them together as in the STEM approach, and they have begun to be viewed as an alternative educational instrument. The inclusion of coding and robotics supports and complements the other STEM subjects like computer applications technology, mathematics, physical sciences and information technology in Grades Four to Nine.

The implementation of CT into STEM education has encountered several barriers, such as not being included in pre-service teacher courses, teachers lacking adequate backgrounds in computer science, and limited resources for integrating CT, which result in a low sense of confidence in teaching and integrating CT in STEM education (Sunday et al., 2024). In a technologically advanced society, learners and teachers need to be adequately prepared to succeed (Govender, 2021).

Studies show that exposure to robotics promotes the uptake of STEM subjects by engaging learners and capturing their interest. When children see abstract concepts in physical form and they are able to play in novel ways, where it engages the brain more deeply and sparks curiosity. Coding and robotics should be brought to learners irrespective of the school's situation in terms of teachers or resources. In highly constrained schools, techniques could include “unplugged” tools, such as board games and the use of basic mobile phones, puzzles or any number of activities that help learners understand the fundamental concepts related to coding.

Robots are technological tools of great interest at all educational levels, especially during the first years of schooling. Robotics presents an opportunity to introduce children from an early age to the world of technology and engineering, offering them significant opportunities to learn mathematical and scientific concepts, as well as to develop 21st century skills. Educational robotics has the potential to help students explore the creative uses of technology, better understand the ever-evolving digital world, and reflect on its advantages and disadvantages (Castro et al, 2023). This supports teaching approaches compatible with the demands of the

21st century, such as constructivism, and promotes the development of curricular learning in STEM areas.

Furthermore, robotics education enables students to develop abstract thinking and a positive attitude toward STEM learning, as well as future STEM career aspirations, at an early age. It also facilitates children's ability to express themselves using technological tools, think critically, and design in an innovative manner. Through robotics, students are able to experiment, design, identify, and solve problems through active learning pedagogies, which facilitate constructionist learning. Such educational programmes create opportunities for children to explore basic technical concepts, experiment with technology, and design and build robots to solve problems. Educational robotics programmes also promote teamwork and active communication between peers and their teachers.

Various studies have been undertaken that demonstrate the contribution of robotics to the motivation and participation of students, the development of their cognitive and social skills, computational and critical thinking, problem solving, creativity, collaboration, decision making, and mathematical and scientific skills (Castro et al., 2023). However, the use of educational robotics is not yet fully incorporated into the compulsory school system. The use of robots to teach mathematics and science is not carried out systematically in all schools, being more an initiative of pioneer teachers. Among the reported barriers to the widespread use of educational robotics as part of the regular curriculum are the lack of teacher preparation to make connections between robotics and STEM subjects, and the failure to develop resources that are accessible in all educational contexts.

The desire to equip young South African students with the skills and knowledge necessary to meaningfully participate in society as scientific citizens seem to have taken a long time for STEM to be included in the educational curriculum at all levels, particularly early childhood. Students' attitudes toward coding can vary greatly based on several variables, including age, experience, and technology exposure. It is critical to comprehend students' attitudes regarding coding and their enthusiasm for STEM occupations because doing so can inform educators and policymakers about the best ways to encourage young pupils at an early stage (Ogebo, & Aina, 2024).

2.13 Unplugged coding

Unplugged coding activities include logic games, cards, and physical movements that are used to represent and understand computer concepts such as algorithms without requiring abstract coding or digital devices (Greyling, 2023). Using unplugged coding will enable many schools to participate as these tools are affordable, and may not be reliant on digital devices. In South African context, unplugged coding could be seen as a Plan B option, where there are no computers available. It could be viewed as an easy way for teachers who do not have computer background. Boz and Alleksaht-Snider (2022) support that coding in schools provides more students with equitable opportunities, and access to learning about it can increase the marginalised group representativeness in the creation of new technologies. Many schools in economically marginalised areas can also benefit from unplugged coding.

An unplugged approach to teaching enables students to explore computational thinking without using a computer (Munasinghe et al., 2023). Unplugged coding in this study emphasises the use of robotics skill, algorithms, internet and eco-communication skills and pattern recognition. Teachers work in groups to construct beads in order to represent binary code. Teachers use arrows or directions to navigate and find the treasure. Teachers draw shapes and patterns using grid paper and instructions. These activities develop problem-solving skills, logical thinking, and creativity without needing devices. Ju (2024) states “unplugged activities teach computational thinking through computer-independent activities that emphasize [sic] foundational CT thinking skills such as logic and problem-solving” (p.8). In this study, unplugged coding is the use of non-digital means to teach a digital technology driven subject.

The teachers are the key people for creating a cooperative learning environment to integrate unplugged coding. Teacher experience in teaching robotics and coding ought to be taken into consideration, where their views and suggestions ought to be known and practiced. Karim et al. (2015) highlight the social utility of robots to help develop children’s cognition and intellect. This research will contribute towards the improvement of teaching coding and robotics in rural schools.

On the other hand, plugged practices make use of computing devices, while unplugged practices do not. Unplugged coding activities involve logic games, cards, strings, or human movements that are used to represent and understand CT concepts, such as algorithms, without

requiring abstract coding. Although the efficacy of these tools for learning to code has been tested in some studies, very few experimental studies involved pre-schoolers, and none of them, to the best of our knowledge, tested the effects of combined unplugged and ER interventions (Montuori, 2023).

Robotic coding activities are also referred to as physical coding. Programming with Scratch for Arduino takes advantage of the fact that an Arduino is a physical device, when paired with Scratch, further making these concepts accessible in a real way (Govender & Govender, 2025). Researchers have reported findings that students are more interested in activities involving real world objects rather than virtual objects, and that students have fun with physical coding and want to stay longer to continue the activities (Rusk et al., 2014). Govender and Govender (2025) outlined that a prominent finding was that physical programming affords the opportunity to learn electronics and programming simultaneously, making programming relevant and interesting. Robotic coding applications, represents software processes that require an abstract process and allow students to directly observe how the codes they have written can work with a hardware after gathering.

Teachers are advised to diversify their programming instruction with such hardware support. It can be said that it is very important to present our students the robotic coding activities that contain the coding activities known to contribute to the "computational thinking" and "programming" skills considered to be among the skills of the 21st century and that can be seen in concrete terms of internet of things and smart devices (Avello et al., 2020).

2.14 Conclusion

Coding and robotics is arguably most important skill that is needed in the 21st century. These are the skills that are demanded in the workplace in this century. Equipping learners with digital skills will increase chances of employment after graduating. The literature shows the importance and challenges that most rural schools face in teaching coding and robotics in rural schools. Many rural schools face a problem of insufficient teaching resources to respond to this problem, where unplugged coding provides the solution for most rural schools.

The next chapter presents the theories that form the conceptual framework that underpins this study with regards to teaching coding and robotics in a rural schools.

CHAPTER THREE: CONCEPTUAL FRAMEWORK

3.1 Introduction

Cherry (2022) explains theory as presenting a concept or idea about why and how a given phenomenon occurs. It provides guidance and give explanation to what is observed. According to Vinz (2022), a conceptual framework is a foundational review of existing theories that serves as a roadmap for developing the arguments to be used in the research. I will use the cognitive load theory and social constructivism on teaching coding and robotics in rural schools. These theories acknowledge that people have different types of intelligence and abilities. By embracing these theories, teachers can improve learning outcomes, boost confidence and develop unique talents.

When designing learning environments, educators must consider several aspects, including learners' prior knowledge, their cognitive capacity and intellectual development, the amount of information to be processed, and the mental load that the learning materials will generate. It is therefore essential that educators, in addition to identifying their learners' prior knowledge, also recognise the capabilities of the cognitive architecture, as this would allow them to make informed decisions about their classroom practices (Skulmowski, 2022).

3.2 Cognitive load theory

Cognitive load theory may provide a way to optimise cognitive processing by drawing on the collective working memory in situations where task complexity is beyond the capacity of the individual's working memory. The theory suggests that collaboration comes with cognitive overheads, due to trans active activities, such as sharing ideas and developing a joint understanding of knowledge, where trans active activities can be managed by developing collaboration skills (Looker, N. 2021).

According to Skulmowski (2022) "the cognitive load theory aims to study the association between people's information processing capacity, defined by the cognitive architecture, their learning, and the instructional design" (p.3). Cognitive load refers to the total working memory resources required to carry out a learning task. It assumes that human memory can be divided into two basic forms, working memory and long-term memory, that the information that is stored in long-term memory takes the form of schemas, and that the processing of new information requires mental effort resulting in cognitive load on working memory which

affects learning outcomes. Cognitive load theory understands learning as the construction of knowledge in long-term memory, which is virtually unlimited in capacity. For that construction, information must first be processed in working memory, which is very limited in both capacity and duration. Although people's working-memory capacity varies somewhat and can be improved through training, it remains the case that any person's working memory can only hold a small number of elements at a time, for a short time (Duran et al., 2022). Understanding cognitive load theory helps educators design learning experiences for each student and their needs.

In cognitive load theory, groups engaging in collaborative learning can be thought of as systems for processing and sharing the knowledge held by the individual members of the group. Collaboration has been shown to have varied effects on cognitive load. It does not affect the perceived content complexity for learners, though it does increase the amount of extra information the learners have to take in when they interact. Collaboration has also been shown to increase the amount of information learners are attempting to process, which shows that it may have conflicting effects on a learner's level of cognitive load, depending on the type of cognitive load measured (Costley et al., 2021).

There are three types of cognitive load whose existence is unanimously accepted by cognitive load theorists: intrinsic load refers to the level of difficulty of a new task or skill; extraneous load represents unnecessary mental effort or cognitive load that does not contribute to learning; and germane load refers to the mental effort invested in learning and constructing new knowledge. One of the core claims of CLT is that our working memory available for the short-term storage and manipulation of information not yet committed to long term memory is very limited, and ought to be carefully marshalled for use in learning (Ellerton, 2022).

3.3 Three types of Cognitive Load Theory

Intrinsic cognitive load

Intrinsic cognitive load (ICL) is determined by the complexity of the material, which is based on the number of interactive information elements requiring simultaneous processing. Element interactivity can be determined by simultaneously considering the structure of the information being processed, as well as the knowledge held in long-term memory of the person processing the prior knowledge (Sozio et al., 2024). Teachers need to use approaches that break down

multifaceted information into reduced, controllable amounts, which can help reduce intrinsic load and increase knowledge.

Intrinsic load emphasises that tasks are logically more challenging, due to their intrinsic characteristics, impacting the degree of cognitive effort required to process them. Understanding intrinsic load is vital for optimising learning experiences, as it helps in designing instructional materials that align with learners' capacities. Understanding intrinsic load can enlighten teachers regarding how to scaffold learning experiences to match the needs of learners with varying backgrounds and skill levels.

Extraneous load

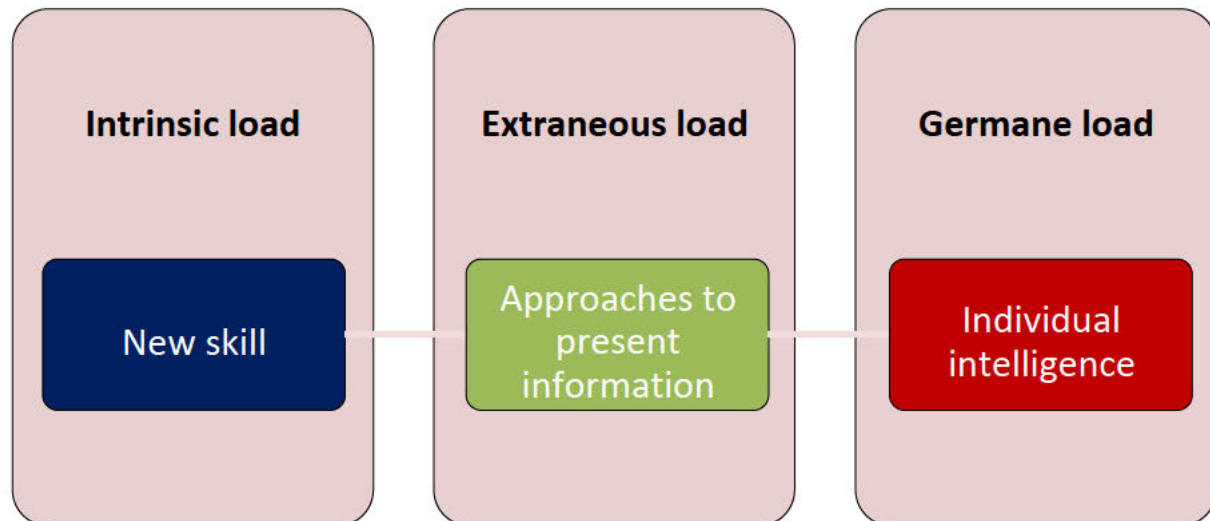
Skulmowski (2022) defines the extraneous cognitive load “as the information that is part of the learning material or instructional design but does not contribute to the student’s learning” (p.4). Extraneous cognitive load is associated with a diversion of cognitive resources on activities irrelevant to learning goals because of design related factors, such as poor presentation design, inappropriate selection and sequencing of learning tasks, or inadequate instructional support. This explains that the extraneous cognitive load, which is also known as wasteful cognitive load, has unnecessary elements of information in the working memory (Hornay, 2021).

Germane load

Germane cognitive load arises when learners actively allocate resources to deal with the task, for example, to build cognitive schemata. In other words, learners use resources that are germane while dealing with them intrinsically, given the requirements of the task (Klepsch et al 2021). The germane load is also referred to as relevant resources since it represents the space in the working memory where previous knowledge is brought from long-term memory to understand the new material. This load is closely related to the learners’ knowledge and to the intrinsic load, since the learners’ prior knowledge can help to manage the intrinsic load through germane load or resources (Skulmowski, 2022).

3.4 Figure 1

The theoretical framework proposed in the teaching coding and robotics in rural schools



Note. Created by Author

New skill

Coding and Robotics as a subject is central to functioning in a digital and information-driven world, that is, to applying digital ICT skills and transferring these skills to solve everyday problems in the development of learners. According to the DBE, 2021 “it is concerned with the various inter-related areas of Information Technology and Engineering, the subject studies the activities that deal with the solution of problems through logical and computational thinking” (p.13). Through Coding and Robotics learners are exposed to a range of knowledge, skills and values that strengthen their aesthetic, creative skills and cognitive development, knowledge through engaging in music and visual art activities, knowledge of digital and ICT skills supported by the technological process and computational thinking skills, and understanding of the relationship between people and the environment, awareness of social relationships, as well as elementary science (DBE, 2021).

The Coding and Robotics curriculum is indispensable to introducing our learners to new technologies within the educational setting, and laying a foundation of knowledge for the intermediate and senior phases in our rapidly evolving technological world. The Coding and Robotics curriculum aims to direct and prepare students to solve problems, think critically, work collaboratively and creatively, and function in a digital and information-driven world. It

also teaches students how to apply digital and ICT skills and how to transfer these skills to solve problems in their daily lives.

Coding is the method by which we speak with a computer to instruct it on what to perform. Coding is part of the process of computer programming. The computer knows what to do, since the programme or code is a set of instructions. It is possible to instruct a computer to handle data, make websites or apps, and make digital games, and many other amazing digital things, by using computer code. Robots are devices that are designed to do specific tasks. Robots come in a wide range of designs and are frequently designed to mimic or reproduce human behaviour. A programmable machine that combines engineering, science, and technology is a robot.

The South African government has committed to the implementation of coding and robotics teaching in primary schools. This vision faces the challenge that 16,000 schools in the country do not have computer laboratories, and that most teachers are not trained to teach coding (Greyling, 2022). In order to promote collaboration, it is recommended that school leaders and other facilitators of teacher collaboration ought to consider individual-, group-, and school level factors simultaneously, instead of focusing their attention on one level and therewith neglecting the other levels (De Jong et al., 2022).

Moreover, beginning teachers are faced with a number of challenges as soon as they take on full-time teaching in a school. They experience anxiety and difficulty in coping with the various challenges they face at the personal and professional level as they try to address students' diverse needs; children coming from different home backgrounds; are assigned to schools that enrol poor, minority and low-achieving learners, they struggle with classroom management concerns. At the same time, given lack of experience, novice teachers tend to be inflexible, finding it difficult to improvise or change plans to suit learners' needs and behaviour (Karlberg, 2022).

Approaches to present information

Understanding cognitive load theory helps educators identify areas that could impact their learner's learning success and find help to remove load burdens. Educators also now understand the impact of the methodologies they use to teach students how to read. Teaching approaches that are too rigid can lead to learner disengagement. Approaches can influence

learners' attitudes towards learning and subject matter. Approaches that emphasis real-world applications and skills can prepare learners for future careers and challenges.

Hands-on coding and robotics activities can be assistive in facilitating learning. Learners should be instructed and guided to design, build, and programme robots to compete. Learners ought to work on real-world projects applying coding and robotics, and to make use of coding games and puzzles in order to engage learners. These approaches help learners develop problem-solving skills, logical thinking, and creativity without needing devices can make coding and robotics more engaging and accessible to all learners

In the absence of the appropriate resources for coding and robotics, teachers ought to increase awareness of unplugged coding so as to widely use such innovative learning environments in the classroom environment (Tongal et al., 2024). The teachers should opt for kinaesthetic activities, paper-based coding, card-based games, role-players, and visual representations.

Unplugged coding makes use of games or activities that can be done offline using tangible objects, such as paper and markers. This could also be referred to as offline or tangible coding, which is a very hands-on approach. In the South African context, unplugged or offline coding could be seen as an Option B where there are no computers available. It could also be viewed as an easy way for teachers who do not have a coding background. Although these considerations are valid, there are, also, many valid pedagogical reasons for introducing unplugged coding (Greyling, 2023).

Individual intelligence

Individual intelligence refers to unique mental qualities of a person, including their capacity to process information, learn, reason, think rationally, and effectively deal with their environment. Intelligence has been defined in many ways to include: higher level abilities, the ability to learn, emotional knowledge, creativity, and adaptation to meet the demands of the environment effectively. People learn and process information differently. Intelligence can be developed and improved through experience and training. Understanding individual intelligence can help tailor learning approaches and appreciate diverse strength.

Teachers ought to be motivated to move beyond merely transmitting knowledge and skills to ensuring that their teaching methods promote holistic development, including the cultivation

of students' emotions, attitudes, and values. Dedicated educators are competent to offer learners new teaching techniques that result in greater success (Shu, 2022). Teachers should prioritise nurturing students' independence and autonomy, guiding them to question, investigate, explore, and learn through practical experience. It is of importance for teachers to create a supportive educational environment that respects students' individuality, addresses their diverse learning needs, and encourages active participation and enthusiasm for learning. Educators are encouraged to demonstrate more compassion towards their students and to work towards creating a positive and conducive classroom environment.

Cognitive overload can be addressed in a few different ways: first, by asking questions of the learner to discover their knowledge level so as to ensure teaching is productive. Second, work to eliminate extraneous distractions, such as cell phones or other devices that may be over stimulating the learner. Third, teachers need to focus on the learner piece of information or task at a time. Considering the amount of time that you can give learners for the task. Being clear about how long something may take can help to reduce the overload.

3.5 Social constructivism

Lev Vygotsky's constructivism theory forwards that human beings can use their mental functions to enhance learning, memory, logical reasoning. The basis of human mental functions to build biologically, and to develop these mental efforts, humans require both society, and culture. Formal and informal interactions between old and young people will give understanding of how children develop (Wibowo et al., 2025). Social constructivism developed from cognitive constructivism, which holds that people learn, create, and employ unique ideas that actively participate in creating meaning for themselves from their experiences through time (Sarwar et al., 2024).

Vygotsky's social constructivist recognises the importance of social interactions and the environmental elements in the learning process. According to Shibina et al. (2022), "the use of cooperative and collaborative learning, as well as projected and discovery learning models, is at the heart of social constructivism, as these practices emphasises the social nature of learning and cognitive apprenticeship, which provides a platform for people to contribute and exchange ideas" (p.376). This theory emphasises the importance of learner-centred learning, where learners are actively engaged in constructing their own knowledge and understanding. Teachers

create learning environment that promote collaborations, critical thinking and everlasting understanding.

The most important characteristic of a constructivist approach to pedagogy is that it can be adapted to the ever-changing teaching and learning habits of the 21st century (Szabó, & Csépes, 2023). Various skills are needed in this century as a result of the digital innovations taking place. It is important for all learners to be introduced to coding and robotics in rural schools. Teachers will be working in groups to discuss how well they are working together, what is working well, and what could be improved. In these groups, teachers will be sharing skills on how best they can introduce unplugged coding in the case of unavailable computers in schools.

The teacher's role is of a facilitator and provides satisfactory resources to the learner so that the learners can experience various approaches. Khalid et al. (2023) explain that social constructivism emphasises group work, collaboration, and communication skills that may lead to reduced individual learning opportunities and less focus on acquiring technical skills required for technical subjects and disciplines. Saleem et al. (2022), “knowledge is socially produced and co-constructed since it requires a community of people who share a language and culture” (p.406). Educators need to have ways to engage and motivate learners to activate their minds and help them be excited about education.

Curriculum redesigning based on social constructivism can be the key toward bringing inclusivity and equality in education. Saleem et al. (2022) state that “Vygotsky believed that social interaction is necessary for lifelong personality development and that social Learning add to cognitive growth” (p.406). Teachers can use any source of information or support to meet the challenge as in the case of group projects. Learning is based on flipped learning, group-based, and inquiry-based learning, are all examples related to constructivism.

Teachers work in groups in order to gain more knowledge on unplugged coding so that they can gain more confidence in their classes. These group will give them deeper understanding of coding concepts. Borko et al. (2024) support that “efforts to understand what teachers do as they work in collaborative groups, and how these experiences lead to improvement in their practice and expertise, have led to a growing interest in examining the different activities, processes, contexts and outcomes for teacher collaboration around the world” (p.4).

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Moreover, beginner teachers are faced with a number of challenges as soon as they take on full-time teaching in a school. They experience anxiety and difficulty in coping with the various challenges they face at the personal and professional level as they try to address students' diverse needs; children coming from different home backgrounds; are assigned to schools that enrol poor, minority and low-achieving learners, they struggle with classroom management concerns. At the same time, given lack of experience, novice teachers tend to be inflexible, finding it difficult to improvise or change plans to suit learners' needs and behaviour (Karlberg, 2022).

3.6 Figure 2

The theoretical framework proposed in the teaching of coding and robotics in rural schools



Note. Created by Author

Social activities

Social constructivism recognises the social aspect of learning and the use of conversation, interaction with others, and the application of knowledge as an essential aspect of learning and a means to achieving learning objectives. According to Mathebula et al. (2024), “social

constructivism emphasises the importance of belonging to a community of practice, where individuals with shared interests and goals collaboratively engage in learning activities and knowledge sharing” (p.91). Teachers will work together to understand better unplugged coding. Teachers share the resources to gather more information. Social activities entail working with peers, experts, and AI communities to exchange ideas, share knowledge, and get diverse viewpoints, ultimately improving the learning experience and driving creativity (Ayanwale et al., 2024).

Introducing group study encourages healthy competition among teachers in order to master the subject, which can also positively impact their teaching and promote their abilities. Constructivism in teaching is crucial in creating a collaborative problem-solving environment for students. This approach encourages teachers to take a more active role in finding solutions to their problems, drawing on their personal experiences, instead of relying solely on instructions.

Engagement and collaborations

Social engagement for pre-service teachers in STEM education involves building positive relationships within the school community, integrating collaborative learning experiences, actively participating in professional networks, and instilling a sense of social responsibility in students (Ayanwale et al., 2024). Emphasis is placed on learning through social interaction. This is done by making teachers to work in groups to solve problems, investigate and explore topics/situations, in order to arrive at conclusions.

One of the education goals that is of great importance for teachers to learn computer-supported collaborative learning environments based on social constructivism principles and to be able to use such environments effectively. It is important to determine the strengths and weaknesses of a learning environment that supports collaborative problem-solving processes and teach them to teachers. In the absence of computers or web technologies, teachers can use unplugged coding. In collaborative learning environments, teachers will be/enabled to effectively apply unplugged coding activities in their lessons and to increase their creativity. Teachers ought to increase awareness of technology-based pedagogical strategies and unplugged coding so as to widely use such innovative learning environments in the classroom environment (Tongal et al., 2024).

Teaching of unplugged coding and robotics in rural schools

Unplugged coding makes use of games or activities that can be done offline using tangible objects, such as paper and markers. It could also be referred to as offline or tangible coding, which constitutes a very hands-on approach. In the South African context, unplugged or offline coding could be seen as an Option B, where there are no computers available. Also, it could be viewed as an easy way for teachers who do not have a coding background. Although these considerations are valid, there are, also, many beneficial pedagogical reasons for introducing unplugged coding (Greyling, 2023).

It will be now possible for the schools to teach unplugged activities since teachers obtained information on group activities. Ju notes that (2024), “Unplugged activities teach computational thinking through computer-independent activities that emphasize foundational CT thinking skills such as logic and problem-solving” (p.8). Teacher collaborations and engagements ensure that teachers have the competence and confidence to integrate CT teaching concepts into the classroom. Through teachers’ social activities, it will be possible for them to better provide students with fun and challenging CT education experiences that maximise their computational skills.

3.6 Linking cognitive load theory and social constructivism

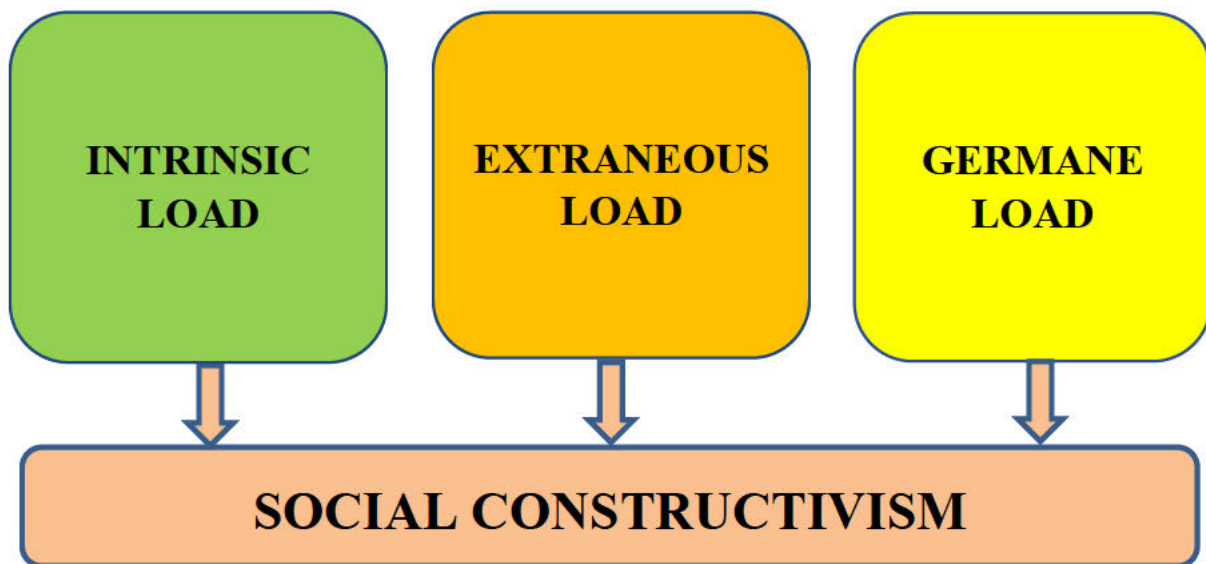
Cognitive load theory focuses on managing mental effort by optimising learning experiences to reduce unnecessary load. Cognitive overload occurs when the combination of intrinsic, extraneous, and germane loads becomes devastating for the learner (Hornay, 2021). When the learner is overwhelmed, they may struggle to process new information or make appropriate decisions. They may fail at a task that ought to be manageable given their knowledge and experience.

Social constructivism is a vital theory in educational psychology, dating back to the seminal work of Russian psychologist Lev Vygotsky that believes that learning is not an isolated, internal process, but one that is deeply rooted in a social and cultural context (Ju, 2024). I believe that cognitive load theory and social constructivism can complement each other by creating more effective learning environment. By managing cognitive load and promoting social interaction, learners can develop deeper understanding and meaningful connections. By

integrating cognitive load theory and social constructivism, educators can design learning experiences that balance cognitive load with social and contextual factors.

3.7 Figure 3

The conceptual framework proposed in the teaching of coding and robotics in rural schools



Note. Created by Author

Intrinsic load theory explained in terms social constructivism

The perceived difficulty of a task can be influenced by social norms, expectations, and support. Social constructivism suggests that learners can benefit from collaborative efforts, which can help distribute intrinsic load and make complex tasks more controllable. More knowledgeable others can provide scaffolding, reducing intrinsic load and supporting learners as they build understanding. Group learning encourage learners to work together to tackle difficult tasks. Almelhes et al. (2024) support that when it comes to social constructivism “the emphasis of group work is placed on the learning that occurs as a result social interaction rather than on the products of the group” (p.2113). By acknowledging the role of social context in shaping intrinsic load, educators can design more effective learning experiences that leverage the power of social constructivism. Coding and robotics are a new subject in which where teachers need to maintain enthusiasm and interest, grasp abstract or intricate ideas. Teachers need to get familiar with the terminology and find reliable study materials.

Extraneous load explained in terms social constructivism

This refers to unnecessary mental effort caused by poor design, unclear instructions, or distractions. If learning materials contain redundant information, learners would spend much of their mental effort on unnecessary information, thereby increasing their extraneous load (Timothy et al., 2023). Coding and robotics can be extraneous to the teachers if they are not fully trained and equipped with relevant resources. Social constructivism emphasises the role of social interactions and culture in shaping knowledge and understanding. Poorly designed social environment can increase extraneous load. Well-designed collaborative learning can reduce extraneous load. Social constructivism highlights the importance of clear communication in reducing extraneous load.

Germane load explained in terms social constructivism

Germane cognitive load is generated by learning activities that support the further development of knowledge structures in long-term memory, such as the application of a learning strategy (Timothy et al., 2023). It refers to the mental effort invested in building meaningful connections and deep understanding. Collaborative learning and discussions can promote germane load. Social constructivism emphasises the role of social interactions in constructing knowledge and meaning. Germane load is increased when learning is contextualised and relevant to learner's social experiences. Foster discussions, debates, and collaborative projects. Teachers need to provide scaffolding and feedback in order to support learners in building meaningful connections. By linking germane load to social constructivism, teachers can design learning experiences that promote deep understanding and meaningful connections.

3.8 Conclusion

Educators with a high degree of self-efficacy are more committed and less prone to breakdown. Teachers are inclined to use inventive educational strategies and encounter greater degrees of work fulfilment. They are faced with frequent alterations in an academic context like syllabus, teaching and academic guidelines. Therefore, in order to improve learners' success educators, need to make greater efforts to provide superior instruction. Teacher commitment to learners embraces educators' inclination to assist learners and take accountability for their education. Commitment to instruction offers educators the right to examine methods of instruction to build learners' educational encounters.

CHAPTER FOUR: METHODOLOGY

4.1 Introduction

A research method refers to a plan on how the researcher will get information to answer the research questions. According to Ernest et al. (2023), “methodology is the method used in conducting the investigation” (p.1433). In any field of research, the methodology serves as the pillar of the study. It is the framework or research design that guides the research process, helping researchers stay on course and ensuring the validity of their results. Understanding the importance of research design is central for fabricating an organised, credible, and scientifically valid study. In this study the researcher will use qualitative methods with quantitative methods limited to descriptive statistics from close ended questions. Muzari et al. (2022) argue that “the methodology in qualitative research focuses on research approach and its design which social science researchers regularly adopt” (p.16).

These research methodologies are important because they provide the researcher with a specific plan to follow throughout their research. A well-defined methodology allows researchers to stay focused on their objectives. It guides them in choosing appropriate data collection techniques, analysis methods, and even how to interpret results, ensuring that the research stays on track. Ernest et al. (2023) note that “researchers using qualitative methodology immerse themselves in a culture by observing its people and their interactions, often participating in activities, interviewing key people, taking life histories, constructing case studies, and analysing existing documents or other cultural artefacts” (p.1433).

According to Taherdoost, 2022 quantitative research is the method of employing numerical values derived from observations to explain and describe the phenomena that the observations can reflect on them (p.54). It also applies the empirical evaluations intending to influence to which degree a norm or standard is fulfilled in a specific policy or program. Eventually, the collected numerical data is analysed using mathematical methods. The researcher will use pie charts, graphs, tables, percentages as examples of quantitative research approach.

This study focuses on topics that are in coding and robotic school subject. To answer these questions, the researcher will discuss the research approach and validate the use of the interpretivist paradigm, research design, sampling, and research instruments used to generate data for this study. It ensures that the procedures and techniques used are reliable and

replicable, which lends credibility to the study. Furthermore, this chapter will outline the trustworthiness of the data generated, as well as the ethical considerations and limitations of this study.

4.1.1 Research questions

Teaching coding and robotics in South African schools has become essential in preparing future generations for the rapidly advancing technological landscape. According Tsotetsi, (2024) “teachers frequently report that the training they receive is broad and neither subject or contextually relevant” (p.03). The researcher is interested to gain deeper information in rural schools regarding coding and robotics. The researcher is aware that coding and robotics have been piloted in several South African schools to equip pupils with the necessary competencies to thrive in a fast-evolving global society.

Moreover, Tsotetsi, (2024) agrees that “training teachers with the use of technology as well as coding and robotics does not only benefit the teacher, but it also benefits the learner because it allows them to learn new things from their teachers, which promotes innovation, collaboration, and creativity in the classroom” (p.01). These four targeted schools were invited by the Department of Education to attend training about coding and robotics. The researcher will research two primary schools and two high school piloting this subject in order to gain insight into various experiences.

Integrating coding and robotics into the school curriculum supports a holistic educational model where learners are not passive recipients of information, but instead, active participants in their learning journey. The researcher used design and methodology aimed to generate data to answer the following research questions. It is an important role in achieving research objectives, its impact on the quality of findings, and why methodology is important in research. The research questions are as follows:

1. What are the experiences faced by teachers in rural school teaching coding and robotics?

Allows the researcher to identify any uniqueness and how do these experiences influence teacher pedagogical practices.

2. How does teaching coding and robotics impact rural schools?

Allow the researcher to examine the effects on student learning outcomes, engagement, and interest in coding and robotics.

3. What are the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools?

Allow the researcher to understand what are the implications for curriculum design and instructional method are.

4.2 Research approach

Qualitative research is defined as the study of the nature of phenomena, including their quality, different manifestations, the context in which they appear or the perspectives from which they can be perceived, but excluding their range, frequency and place in an objectively determined chain of cause and effect (Busetto et al., 2020). The results of qualitative methods are more descriptive, and the inferences can be drawn quite easily from the data that is obtained. Muzari et al. (2022) support that “the basis of it lies in the explanatory approach to societal realities, and in the description of the lived and reflected experiences of human beings” (p.15). Qualitative research methods originated in the social and behavioural research sciences. In this research various teachers will be requested to share their experiences to coding and robotics.

Qualitative methods have emerged as crucial tools for gathering deep insights and understanding complex phenomena. This guide endeavours to explain the process of qualitative research by offering a comprehensive overview and pragmatic strategies to navigate its multifaceted dimensions. It delves into the rich textures of human experience and perspective, capturing contexts and nuances often lost in numerical translation. Engaging with qualitative research is not just a methodological choice but a commitment to exploring the depths of social phenomena, enabling researchers to connect with the subjective experiences of their subjects (Lim, 2024).

Qualitative research stands out for its unique ability to capture the richness of social phenomena involving human experiences and perspectives. It explores the core reasons that underscore the necessity, importance, relevance, and urgency of qualitative research. Offering insights into

complex social phenomena, generating human-centered understandings, connecting with real-world issues, and responding rapidly to social changes, qualitative research plays an indispensable role in a world increasingly characterised by complexity (Lim, 2024).

The researcher selected qualitative research method because it will enable the participants to share their unique experiences. Muzari et al. (2022) magnify why “researchers aim to understand experiences drawn from the context of real situations” (p.15). These participants come from various schools and encountered unique experiences. It is the most open-ended form of a data collection. The data is expressed with words, it can offer insights that numerical data cannot and is generally much more flexible in nature. It provides direct responses to research questions. It can also suggest areas for further exploration.

The qualitative research method is ideal to this study, due to speed with which information can be collected. The researcher will use approximately four weeks to gather the information. The data will be collected instantly through verbal communication and keeping the time and cost expenditure low. It will allow the researcher to meet and interact with the participants. Various teachers will share their experiences as questionnaires, observation and interviews will be executed. This method will allow the research to understand the behaviours and attitudes of teachers.

4.3 Research paradigm

A paradigm defines existing knowledge, the nature of the problem to be investigated, appropriate methods of investigation, and the way data should be analysed and interpreted. In this study the researcher will use interpretivism. It is an approach to social science that asserts that understanding the beliefs, motivations, and reasoning of individuals in a social situation is essential to decoding the meaning of the data that can be collected around a phenomenon (Nickerson, 2022).

The interpretive paradigm is ideal in this study because it offers a unique lens through which researchers can understand social phenomena. It enables the researcher to understand people's experiences. The emphasis on qualitative research methods, the acknowledgement of reality as

a socially constructed entity, and the exploration of subjective experiences contribute to a nuanced understanding of human interpretation and interaction. Interpretive approaches within the social sciences highlight the importance of researchers recognising and understanding the variations among individuals (Acharya, 2024).

This paradigm offers the researcher a background that aligns with the complexities of human interpretation and interaction, guiding them in conducting studies that explore into the rich wall-hanging of subjective experiences within social contexts. This makes research a socially created activity, which means phenomena is created by society and not naturally occurring. Interpretivism allows the researcher to collect qualitative data using a variety of techniques. The researcher will use questionnaires, observation, and interviews based in focus groups to gather the information.

Interpretivism is originally rooted in the fact that methods used to understanding knowledge related to human and social sciences cannot be the same as its usage in physical sciences because human interprets their world and then acts based on such interpretation, while the world does not (Lan, 2018). Interpretive approaches rely on questioning and observation in order to discover or generate a rich and deep understanding of the phenomenon being investigated. The four teachers per four different schools in Alfred Nzo West District will be asked to share their experiences in teaching coding and robotics. This is closely associated with qualitative methods of data collection. A study by Gemma (2018) supports that the “interpretivism argues that truth and knowledge is subjective, as well as culturally and historically situated, based on people’s experiences and their understanding of them” (p.18).

4.4 Research design

A case study approach will be used in this research. According to Clark et al. (2021) “a case study involves detailed exploration of a specific case, which could be a community, organisation, or a person, but you cannot gain data by simply selecting an organisation and deciding to study it intensively” (p.3). Case studies are a qualitative design in which the researcher explores in depth a programme, event, activity, process, or one or more individuals (Arya, 2020). Nevertheless, there will be some data that maybe quantified and will be analysed through graphs, percentages, and numbers. This case is bound by time and activity, and I will

collect detailed information using a variety of data collection procedures over a sustained period of time.

Qualitative research which is supported by interpretivism; hence I will have approximately 16 teachers who will be participants come from different schools in terms of infrastructure, internet connectivity, computers availability. The researcher will use case study to understand different perspectives of teachers from various schools. Martinsuo et al. (2021) substantiate that “the obvious feature of a case study is that it investigates a phenomenon in its natural context, in a real-life setting” (p.1).

The researcher’s reason to use the case studies is to gain an in-depth exploration of about people, processes, events, and programme. The structure of a case study stems from the issues, contexts, problems, and even the learning lessons from the events (Taherdoost, 2022). Case study research is an intensive, longitudinal study of a phenomenon at least one research site that intends to derive detailed, contextualised inferences and understand the dynamics that underlie the phenomenon that is being studied (Acharya, 2024).

Furthermore, a case study is richly descriptive because it is grounded in deep and varied sources of information. It uses quotes from key participants, anecdotes, other literary techniques to create mental image that bring to life the complexity of the many variables inherent in the phenomenon being studied (Hancock et al., 2021). There are several techniques of data collection employed in this study, namely: questionnaires, workshops and observation, and interviews.

4.5 Selection of participants

4.5.1 Location and context

The Alfred Nzo West District contains the following towns: Mount Frere, Mount Ayliff, Maluti and Matatiele. It is the smallest and one of the poorest districts in the province of Eastern Cape. Similarly to other South African rural communities, rural communities in the Alfred Nzo District are entrenched in poverty, excessive unemployment rates, especially for young people, high teenage pregnancy rates, with many school dropouts and crime. The Alfred Nzo District is part of what was previously referred to as the Transkei homelands. This District is

categorised as one of the presidential nodes in the rural development plan due to its high poverty resulting from income inequalities and very low levels of development (Mkuzo et al., 2025).

Most of the schools are located in rural areas where unemployment and poverty is evident. Similar to other South African rural communities, rural communities in the Alfred Nzo District suffer from widespread poverty, excessive unemployment rates, especially for young people, high teenage pregnancy rates, many school dropouts, and crime. A majority of the schools in this district do not offer computer-related subjects (Computer Applications Technology and Information Technology) to their learners, because generally there is a shortage of computers in these schools. The home languages in this district are isiXhosa and Sesotho. A majority of teachers in this district are Africans. Four schools, which consist two primary and two high schools, were chosen to participate in this study (Mkuzo et al., 2025).

4.5.2 Target population

According to Rahman (2022), “the target population is a group of people or items about which researchers wish to make broad generalisations” (p.46). Also, Simkus (2022) supports that the sample is the participants you select from a target population to make generalisations about. An entire population tends to be too large to work with, so a smaller group of participants must act as a representative sample. It consists of teachers who had introduced coding and robotics and those who did not. Teachers with experience and those without it are the target in this research. The teachers will come from primary and high schools. Target population are lead teachers overseeing the implementations of coding and robotics in rural schools in Alfred Nzo West district in Eastern Cape Province.

In 2005, the South African Schools Act was amended to make provision for a tiered funding policy for public schools, in the hope that the application of the principles of redress, equity, quality, access, and efficiency might create conditions favourable for the attainment of targets for education. Given the extent of poverty and unemployment in the country and the diminished capacity of citizens to afford the costs of public schooling, the state created the quintile ranking system, a system that differentiates school funding allocations on the basis of the unemployment and literacy levels of the communities in which each school is physically located. Quintile 1, 2, and 3 schools are classified as “no-fee schools” and are granted an annual

allocation per child that is higher than the funding allocated (per child) to more affluent schools (in quintiles 4 and 5) (Maistry, 2022).

The first school to be researched is the primary school classified as Quintile 2 as a no-fee institution; there are no tuition fees for students attending this school. The focus is on foundation and intermediate phase, Grade One up to Grade Six. In this school, teaching technologies are available in bad conditions. A majority of the equipment (computers) are not working due to depreciation. Educators were twice invited to attend the workshop that was organised by the Department of Education.

The second primary school is the former private school, it is located in a small town, where the focus is on Grade One up to Grade Six. The school is a public school categorised as Quintile 4, tuition fees are determined by the school administration to cover operational expenses and educational resources. The infrastructure in the school consists for proper classrooms, computers and learners are introduced to computers.

The third school is the high school located in rural areas, focusing on Grades Eight and Nine. This school has average infrastructure, including buildings, furniture, computer labs and equipment. School operates as a no-fee institution under South Africa's policy, which ensures education accessibility regardless of financial status. Government funding covers essential expenses, eliminating fees to promote inclusivity and equal opportunities for all learners, facilitating quality education environments conducive to academic success. The school is classified as a Quintile 2 institution. Many school children in South commute to schools outside of their neighbourhoods in search of better learning environments.

The fourth school is a high school, also Grade Eight and Nine, well known for good performance and consistence in matric results, located in remote areas with poor school infrastructure. In this school, computers are available, but in limited quantities. This is a public school designated as Quintile 1 as a no-fee institution, there are no tuition fees for learners attending here. This school is piloting coding and robotics. Teachers and learners in this school were invited to attend coding and robotics workshop in Cape Town. Some pupils are able to attend robotics workshops at the Cape Town Science Centre as an extra mural activity; however, there is a fee required to attend these sessions (Mondada et al., 2016).

Moreover, in these communities there is poverty, poor housing, inadequate skills development, lack of energy sources, inadequate drinking water and sanitation, poor communications, poor education and training, lack of transport, lack of sporting and recreational activities, and cultural deprivations are just a few of the factors that have led to disadvantages for these students.

4.5.3 Recruitment phase

I firstly wrote the letter to the district director of Alfred Nzo West requesting to visit the schools for researching about coding and robotics. Thereafter, I made appointments with the four principals: two primary and two high schools, I explained the nature of the study to them (appendix E). Then, I requested from the principals to meet the educators. To the educators I explained the nature of the study and gave them an information sheet with a consent form to grant the research permission (Appendix F).

4.6 Sampling

The sampling method is important to strengthen the representativeness of the sample (Stratton, 2021). Sample refers to the group of teachers selected to represent the entire population. It represents approximately sixteen teachers from four different schools of Alfred Nzo west that will represent entire schools. Ahmand et al. (2023) argue that “studying the entire population can be impractical, time-consuming, and costly, researchers use samples to gather data and conduct analyses that provide insights into the characteristics and behaviours of the larger group” (p.22). I therefore decided to take this route.

4.6.1 Sampling procedure

According to Rahman (2022), “the primary aim of sampling is to obtain a representative sample composed of a small number of units or instances drawn from a much larger group or population” (p.43). The study uses non-probability sampling methods, which are less objective than probability techniques and is a type of sampling in which the researcher uses sampling that does not provide for each member of a target population to participate in a study, where instead, the participants are selected by the researcher, are referred to the researcher, or self-select to participate in a study (Stratton, 2021). The researcher will use purposive research sampling.

According to Cresswell et al. (2017) the purposive sampling method involves selecting samples from the overall sample size based on the judgment of the survey taker or researcher. It is also known as judgmental, selective, or subjective sampling, and relies on the researcher's judgement when it comes to selecting the units that are to be studied. Usually, the sample being investigated is quite small, especially when compared with probability sampling techniques. The participants will consist of approximately sixteen teachers from four different schools of the same district. Two experienced teachers and two novice teachers from each school will be requested to participate in this research.

In this study experienced teachers are those who have been in the education field for more than five years. On the other hand, novice teachers are those that are still fairly new in the teaching field with less than five years of experience. Teaching experience can be considered as a period of intense transition as a novice teacher takes on the responsibilities of planning instruction, teaching, assessing students, and managing a classroom (Stewart et al., 2022). In this research, a total of eight participants will be experienced teachers mostly in school management team.

4.6.2 Purposive sampling

Purposive sampling is about selecting the best, information-rich, relevant, broad-ranging, and plentiful data available to gain insight and in-depth understanding by creatively solving puzzles with convincing evidence. Purposive sampling demands that the researcher exercise their best judgement by intentionally inviting those people or selecting locations, documents, or artefacts that can help accomplish these tasks (Staller, 2021). The researcher has prior knowledge about the chosen participants and they will fit and represent the greater population of interest.

According to the DBE, it is looking forward to the piloting of the draft Coding and Robotics Curriculum Grade R-3 and 7 during the third term of the 2021 academic year. The full-scale implementation for these grades is planned for the 2023 academic year. The pilot for Grades Four-Six and Grade Eight was planned for 2022, and will be followed by a Grade Nine pilot in 2023. The full-scale implementation for Grades Four-Six and Grade Eight is planned for 2024, and for Grade Nine in 2025 (Department of Basic Education, 2019). The researcher chose to use two primary and two high school since the coding and robotics has been piloted. The researcher wants to gather more information as possible.

Purposive sampling is an approach that acknowledges that researchers use their own judgment and expertise to choose participants (Zickar et al., 2023). It is also known as judgmental, selective or subjective sampling. Purposive sampling relies on the judgement of the researcher when it comes to selecting the units that are to be studied. The participants will be approximately sixteen teachers, total of four teachers per school. It is likely that there was little intervention in terms of professional development in equipping teachers for coding and robotics. I purposively sampled schools who have attended the workshops about coding and robotics.

With the aim of promoting robotics, South Africa has hosted educational events such as the First Lego League South Africa, First Tech Challenge South Africa and the World Robotics Olympiad, and has participated in the RoboCup Junior contest sessions (Mondada et al., 2016). They frequently encourage both autonomy and collaboration within each team of participants. Unfortunately, such activities and events are often restricted to the upper-class schools, which have computer facilities, an internet connection, and teachers who are enthusiastic about educating their students with the help of resources that are superior to those available in the normal syllabus. For example, some pupils are able to attend robotics workshops at the Cape Town Science Centre as an extra mural activity; however, there is a fee required to attend these sessions (Mondada et al., 2016). One of the schools included in this study attended the workshop in Cape Town.

Table 1

Duration	Activities	Data collection tool/further details
Week 1	All teachers are expected to share their experiences with the subject coding and robotics. Each school will be represented by four teachers.	Questionnaires A

Week 2 up to 3 Taken place on the Monday 14/04/2025 Workshop 1: will consist a maximum of three hours	All teachers learning about unplugged. Workshop 1: Robotics Skill	Workshops and observations In each workshop Activity 1 will be guided and Activity 2 will be unguided team/group work. During each workshop there will be an observation done. After each workshop each teacher will complete questionnaire B In each workshop teachers to share the experiences of non-digital means in a rural context semi-structured interview
Wednesday 16/04/2025 Taken place on the Workshop 2: will consist a maximum of three hours	Workshop 2: Internet and E-Communication Skills	
Tuesday 22/04/2025 Workshop 3: will consist a maximum of 2 hours	Workshop 3: Algorithm	
Thursday 24/04/2025 Workshop 4: will consist a maximum of two hours	Workshop 4: Pattern recognition	
Week 4	All teachers to share how would coding and robotics impact rural schools based on their experiences of workshop series	Focus group semi-structured interviews.

Note. Planning for data collection

The researcher in purposive sampling will use judgment and planning to select a sample of individuals that will benefit the study. Muzari et al. (2022) argue that “it is used in case study when working with small samples where selected cases are particularly informative about the subject under the study” (p.16). The researcher purposively sampled four different schools in Alfred Nzo West district in Eastern Cape who have an exposure to coding and robotics. These schools were all invited to attend coding and robotics workshop by the Department of Education and district and some schools in provincial level. One primary school and one high school within the sample are piloting coding and robotics.

4.7 Research execution

In each school, four teachers were asked to participate (2 novice and 2 experienced), the total number of participants were sixteen. Teachers are divided into three phases per week: the researcher first presented this study to the Department of Basic Education, the school principals, and the teachers of identified schools to ask the permission to conduct the research on teaching coding and robotics in Alfred Nzo West district (appendix D). The researcher worked with approximately sixteen teachers; each school had a representative sharing their experiences with coding and robotics.

4.8 Data collection methods

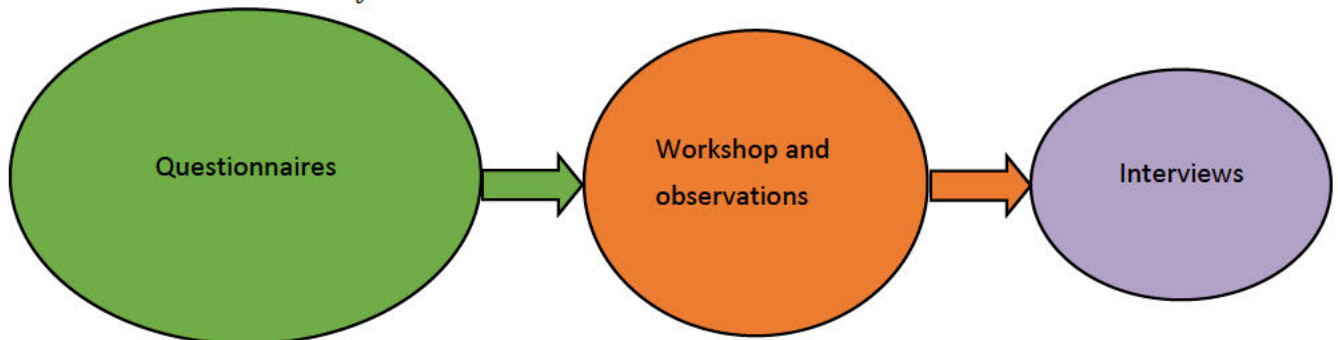
Data collection involves activities that aim to discover and understand what data is available and how to organise and organise convenient storage for it (Paleyes et al., 2022). Data collection refers to the process of collecting data aiming to gain insights regarding the research topic (Taherdoost, 2021). The researcher will ensure that data is complete during the research process and collected legally and ethically. The data collection methods that will be used are questionnaires, workshops and observation and interviews on focus groups.

Data collection is a fundamental phase in any research process, playing a critical role in determining the success of a study. It involves gathering information that will be analysed to answer research questions, test hypotheses, and ultimately achieve the research objectives. Ganesha et al. (2022) support that “choosing an appropriate research approach/reasoning that paves path for decision concerning data collection and analysing” p.499. The quality of the

data collected directly influences the validity and reliability of the research findings, making it essential to choose appropriate data collection methods.

Figure 4

Note. Indicates the order of data collection and methods



Note. Created by Author

4.8.1 Questionnaires (appendix G)

According to Sharma, 2022 “A questionnaire is a research tool that asks respondents to answer questions in order to gather pertinent data” (p.2). A questionnaire refers to a list of questions or items used to gather data from respondents about their attitudes, experiences, or opinions. The questionnaires consist of 15 questions and will be delivered manual to all sixteen participants at their different schools. The participants will have one week to respond to these questionnaires, the researcher will then visit again the school to collect the responses of the participants.

The questionnaire is mainly qualitative in nature, and involves a series of closed and open-ended response questions. The respondents are required to write the responses below the questions as provided. Some questions merely require X in questionnaire A and B on the relevant answer. Information can be collected relatively quickly, because the researcher would not need to be present when completing the questionnaires.

4.8.2 Workshop

The expanded topics covered in the foundation phase are expanded as follows (Department of Basic Education South Africa, 2021a): Pattern Recognition and Problem-Solving, Algorithms

and Coding, Robotic Skills, Internet and E-Communication Skills and Application Skills. The workshops and observation are for the Foundation Phase where teachers and senior phase teachers. The teachers of the same school will work in group and the researcher will guide them on the four activities: robotics skills, internet and e-communication skills, algorithm, computation thinking and pattern recognition.

According to the Department of Education (2019) the importance of teaching coding and robotics topics are as per Table 2.

Table 2:

Topics as per Coding and Robotics CAPS (page18)

Topics	Importance of the topics
Robotics skills	• Robotics help learners to think creatively and critically • Encourage learners to think outside the box and come with original ideas • Enables learners to increase their problem-solving abilities • Helps learners to learn 21st century skills • It develops teamwork and collaboration skills in learners
Algorithm	• Enable learners to bread down complex tasks into manageable steps • Allows learners to approach challenges systematically and logically • Improves problem-solving skills • Provide a structured approach to problem solving • Help to predict trend, optimise and solutions
Internet and e-communication skills	• Provide a vast source of information • Promotes flexible access to education • Improving learner engagement and critical thinking
Pattern recognition and problem-solving	• Allows learners to process and retain knowledge more effectively

	• Develop problem solving skills allows students to approach new challenges with flexibility, generate creative solutions, and adapt to changing situations. • Enables individuals to identify and interpret patterns in information • Develop effective solutions to complex problems
Computation thinking	• Encourages learners to reflect clearly on a problem they are solving and intentionally define a repeatable solution for it • It fosters problem-solving, critical analysis and logical reasoning.

Note. Topics for the workshops

Each workshop will be based on the four topics demonstrating unplugged strategies. Teachers (participants) will work as group in each school. These workshops are focused on the teacher's reflection and reasoning to construct their own learning. It is identifying what they already know, what they need to know, the how and where to access new information that may lead to the resolution of the problem. The role of the teacher to study in groups is to facilitate learning by supporting, guiding, and monitoring the learning process.

The teachers of the same school will work together in order to implement unplugged. Through teacher collaborative experiences, teacher shared ideas, negotiated meanings, and constructed knowledge about scientific principles and twenty-first-century skills, such as critical thinking, creativity, and communication. When teachers are engaged, they are more likely to ask questions, seek additional resources, and apply the material to their own experiences. In so doing, they discover or construct knowledge by themselves and able to execute unplugged after working in groups. Encouraging teachers' interest in and learning of STEM courses helps build their confidence and capability in making these subjects accessible and enjoyable for their future students.

4.8.3 Observations

Observation enables the researcher to observe teachers teaching unplugged. These activities include logic games, cards, and physical movements that are used to represent and understand computer concepts such as algorithms, without requiring abstract coding (Greyling, 2023). Using unplugged enables many schools to participate as these tools are affordable. In South

African context, unplugged could be seen as a Plan B option where there are no computers available. It could be viewed as an easy way for teachers who do not have computer background. Boz and Alleksaht-Snider (2022) support that coding in schools provide more students with equitable opportunities and access to learning about it can increase the marginalised group representativeness in the creation of new technologies. During each workshop an observation schedule were be completed. Observations provide evidence to the data obtained.

4.8.4 Semi-structured interviews

Mwita (2022) emphasises that “Interview, which is considered to be the most common method of collecting qualitative data, involves conversations with informants for the purpose of collecting data” (p.415). The research uses interviews that allow the researcher to easily understand the actual feelings of the respondents on coding and robotics. During the interviews, teachers are encouraged to share the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools. Semi-structured interviewing is used in this study for the purpose of collecting teachers’ responses for this research. Interviewing is an effective strategy to acquire data for qualitative research using case studies as a research methodology.

Moreover, it helps to explain, understand, and explore research subjects' opinions, behaviour, and experiences to narrow down the area of research that researcher is interested to discover while listening to them being involved through dialogue. Therefore, semi-structured interviews become effective tools of knowing the experiences and perceptions of research subjects relating to central themes of area of investigation (Naz et al., 2022).

The researcher is gathering a group of teachers, typically between four-six participants with shared characteristics, such as age or educational background. The goal is to uncover insights through group dynamics and interactions, often in a semi-structured format guided by a facilitator. The researcher carefully managed the conversations to ensure there is enough participation of each member so that adequate amount of data is collected.

4.8.5 The different data collection tools will be used to answer the following research questions:

Table 3:

Data collection tools with the research questions

Data collection tool	Research questions
Questionnaires	1 What are the experiences faced by teachers in rural school teaching coding and robotics?
Observation and workshops	2. What are the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools?
Interviews	3. How does teaching coding and robotics impact rural schools?

Note. The data collection tools

4.9 Data analysis

Qualitative data analysis is the classification and interpretation of linguistic material to make statements about implicit and explicit dimensions and structures of meaning-making in the material and what is represented in it (Jowsey et al., 2021). Waraas (2022) explains “thematic analysis is a method for systematically describing and interpreting the meaning of qualitative data by assigning codes to the data and reducing the codes into themes, followed by an analysis and presentation of these themes” (p. 154). The research uses questionnaires, workshop and observations and semi-structured interviews to collect the data and thematic analysis was used to analyse the data collected.

Thematic analysis is a flexible and systematic way of making sense of qualitative data. The thematic analysis involves identifying, analysing, and reporting patterns (themes) within the data, with the aim of capturing something important in relation to the research questions (Proudfoot, 2023). The research uses it to analyse and provide a clear and compressive account for analytical process, enabling others to understand, evaluate and build on the study. The researcher executed the following steps to analyse the data:

Step 1: Familiarisation with the data.

The research starts by studying the data. Before starting the analysis, the researcher goes through the data several times. This data is generated from questionnaires, observations and interviews on focus groups. The researcher reads and re-read the dataset and note important ideas. The researcher gains a deep understanding of the content and context of the data.

Step 2: Coding the data

Coding refers to the creative link between data collection and data analysis, based on data selection (Jnanathapaswi, 2021). This process is sometimes referred to as pattern coding, a method of collapsing the codes created during open. In this process of identifying patterns and collapsing codes, the researcher can begin to identify themes. The goal of this is to organise the data into manageable chunks without losing its essence.

Step 3: Searching for themes

Themes are developed by synthesising the remaining inductive codes into theme statements that describe the patterns seen in the data (Bingham, 2023). Look for the patterns in coded data and group similar codes together. These groups will inform potential themes.

Step 4: Reviewing themes

Reviewing the themes against the dataset to ensure they are supported by data and remain consistent across the dataset. This may include refining the themes, splitting, combining or discarding them as needed. After grouping, the researchers identified whether the abstraction process should be continued by grouping sub-concepts together based on similarities in content (Cueto et al, 2022).

Step 5: Defining and naming themes

Themes, often called ‘concepts’ or ‘categories’ among other terms, can be identified before, during and after data collection and analysis (Mishra et al., 2022). This involves determining the essence of what each theme is about and what aspect of the data each them captures and assign clear and informative names to each theme.

Step 6: Producing the report

The researcher provides clear and compelling data extract to illustrate each theme, ensuring that data analysis provides a rich, detailed, and complex account of the data. The reporting step referred to the systematic and logical reporting of the analysis results. In this step, the researchers described the contents of the presented concepts through the identified subcategories and open codes by providing authentic citations that connect the results and raw data.

4.10 Trustworthiness

Trustworthiness refers to the degree of confidence in data, interpretation, and methods to ensure the quality of a study. The researcher understands policymakers to depend on strong evidence to create well-informed and adaptable policies that tackle social concerns and foster fair outcomes. Trustworthy qualitative research findings are also important for informing policy decisions and enlightening the delivery of services in various fields (Ahmed, 2024). These are important aspects of trustworthiness in qualitative research are triangulation, validity, credibility, dependability, confirmability and transferability.

4. 10.1 Triangulation

Triangulation is a research method that involves using multiple sources of data to validate findings. In this research, many data collection methods are used to gather information. The researcher uses questionnaires, workshop and observation, and interviews. Bans-Akutey et al. (2021) support “making use of multiple data sources reduces research biases in sampling, procedural bias as well as researcher biases thus increasing validity and credibility” (p.4), while on the other hand, Donkoh et al., (2023). support that “triangulation helps researchers to overcome biases associated with the use of single-observer, single-method, and singletheory.¹³ Overcoming these biases result in confirming results and conclusions” (p.7).

Triangulation also helps to enhance the generalisability of research findings. By using multiple sources of data, researchers can ensure that their results are not limited to a specific context. This method allows the researcher to gain a more comprehensive understanding of coding and robotics in rural schools. Donkoh et al., (2023) agree that “triangulation is often used by methodologists to validate and confirm qualitative results with the results of quantitative studies (p.06). Another advantage of triangulation is its ability to provide a more complete picture of a phenomenon.

4.10.2 Validity

The research conducted should show high degree of validity, meaning that it should serve the purpose. According to McLeod, (2023), the concept of validity states that the test is valid if it measures what it claims to measure. Validity refers to how well the research measures what it intends to measure, and how accurately it reflects the reality of teaching coding and robotics in rural areas. The researcher understands that, when providing reliable information, informed decisions can be taken.

4.10.3 Credibility

Credibility is a measure of the truth value of qualitative research regarding whether the study's findings are correct and accurate. According to Creswell et al. (2017, p. 238) "reliability is the extent to which a measuring instrument is repeatable and constant". Reliability shows how consistent and stable research results are, and how well they can be replicated by other researchers. Ahmed and Ishiaq (2021) supports that reliability and validity are among the most important and fundamental domains in the assessment of any measuring methodology for data collection in good research. This research will capture the actual experiences and perspective of participants.

4.10.4 Dependability

Dependability pertains to the enduring and unwavering nature of the research findings across time. In order to assure reliability, researchers rigorously document questionnaires, observations and semi structured interviews as techniques for data gathering, and procedures for analysing. The researcher will document each step of the research process to ensure transparency and allows others to replicate the study or assess the dependability of the findings by following the same procedures and understanding the rationale behind decisions made (Sirwan, 2024).

Dependability refers to the standard by which the logic, reasoning, methods, and results are expected to be stable or consistent over time. It ensures that the results are based on the experiences and preferences of the participants, rather than those of the researcher. The logic used for selecting people and events to observe, interview, and include in the study should be

clearly presented. The more consistent the researcher has been in this research process, the more dependable the results (William et al., 2022).

4.10.5 Confirmability

Kasirye (2021) argues that “The interpretation should not be based on the researcher’s preferences and viewpoints but rather, it needs to be grounded in the data” (p.5). Confirmability refers to the standard by which a qualitative study is expected to be supported by informants (participants) who are involved in the study and by events that are independent of the researcher. Reference to literature and findings by other authors that confirm the researcher’s interpretations can strengthen confirmability of the study in addition to information and interpretations by people other than the researcher from within the inquiry site itself.

Responses from questionnaires will be kept aside as they will be providing different experiences of the participants. The researcher confirms conformability by using a smart phone voice recorder during interviews. This will allow the researcher to capture the exact words of the participants, which can be changed into written data, permitting for themes to be created. In the case of workshop observations, pictures of group work will be taken to show the work that was done in different groups. Consent will be asked before taking the pictures and their faces will be made blurry.

4.10.6 Transferability

Haq et al. (2023) clarify that “transferability shows the degree of application of the research finding in other exact natures of context, people, groups, and settings” (p.155). This can be addressed with a diverse sample of participants from different locations and sectors, by comparing and connecting the research findings with prior theory, and by explicitly outlining any identified limitations and recommendations for further research (Makri et al., 2021).

Transferability is a process of abstraction used to apply information drawn from specific persons, settings, and eras to others that have not been directly studied. It is often linked with generalisation, a similar process that is much more widely discussed in the social science literature. Transferability as a research concept was introduced by Lincoln and Guba (1985) in their continuing effort to distinguish the yield and use of interpretive qualitative research results from positivist conceptualisations aiming for law-like prediction and control (Drisko, 2025).

4.11. Limitation

Limitations refer to those factors that the researcher has no control over. In this study, 16 teachers from four different schools will be the participants, which is not a representation of a larger population. The research uses a case study; therefore, the study is not generalisable. According to Creswell et al. (2017, p. 192). “It is usually impossible to include the entire population in your study, the two main restrictions being time and cost” I will conduct questionnaires, observations and interviews only in four schools in Alfred Nzo District in the Eastern Cape. As a delimitation, I am restricting the study to approximately 16 teachers from four different schools in this district. I will make a point that other participants are available in the case if some decides to withdraw.

4.12 Ethical clearance

Ethics Reference Number: HSSREC/00007420/2024 (appendix C).

Karunaratna et al. (2024) provide the following definition: “Ethical considerations help protect the rights, privacy, and well-being of participants while ensuring that the research is conducted responsibly and transparently” (p.18). The researcher required a clearance certificate from the University of KwaZulu-Natal, which granted permission to conduct the proposed study. Additionally, the researcher required written permission from the Department of Education and the school principals to conduct research at school.

According to Creswell et al. (2017), p. 192 “an essential ethical aspect is the issue of protection of the participants’ identities”. The consent form will outline the details of the study with the option of withdrawing at any stage of the research. Prior to any letters being issued, full ethical clearance will be obtained to conduct this research. Confidentiality, honesty, respect human dignity, privacy, and autonomy; take special precautions with vulnerable populations. The results from the study will be qualitative nature, however, the names of the participants will not be revealed. The researcher will not use participant’s real names, teachers in their schools will be called SAT1, SBT1, SCT1, SDT1 etc., and pseudonyms will be used to protect the identity of the participants.

Participation in the study will be voluntary, and none of the participants will be made to feel uncomfortable or violated during the study of teaching robotics in rural schools. I will take responsibility to make sure that participants’ rights are not infringed upon, and that they feel

safe during the entire process. Regarding consent, permission will be asked from teachers, school principals, and Department of education in Alfred Nzo West.

4.13 Conclusion

This chapter presented the research design and methodology used to conduct the study. This study was underpinned by the interpretivist paradigm, which was the most effective way to investigate deeper and understand the experiences of educators who teach coding and robotics and those who did not introduce it. In this research questionnaire, workshop and observation and semi-structured interviews will be used to gather the information. The ethical clearance was obtained at University of Kwa-Zulu Natal to begin the study, also the DoE and participants in schools agreed and signed the consent form.

CHAPTER FIVE: DATA ANALYSIS

5.1 Introduction

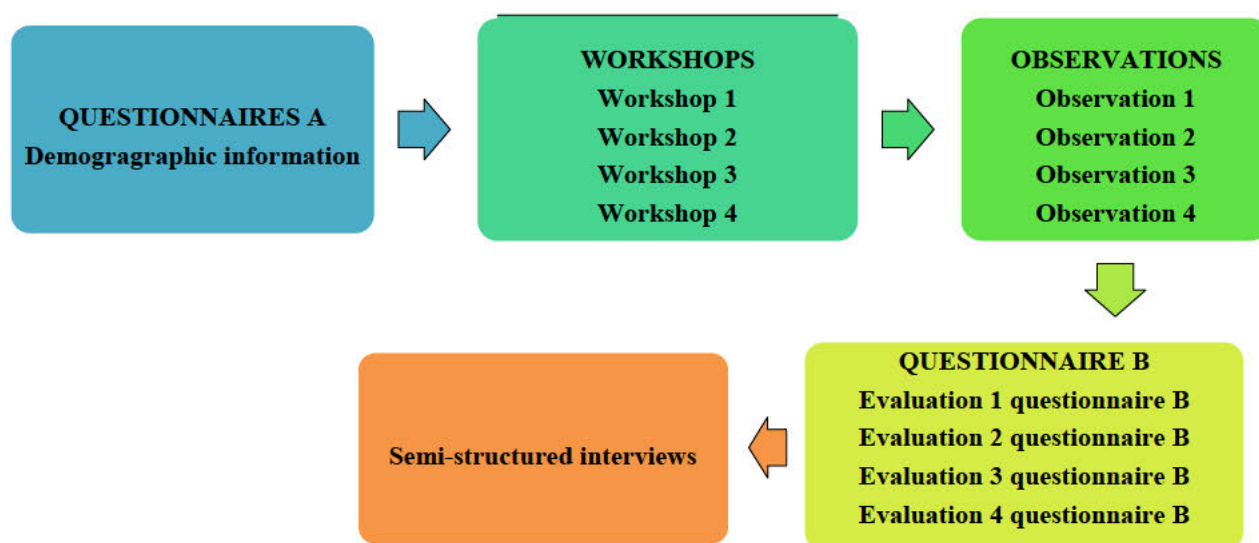
The previous chapter presented the research methods used in this study to accomplish the research objectives and address the research questions. The purpose of this chapter is to present the analysis and findings of the data collected through the use of data collection tools. This

chapter analyses the data from a total 16 respondents that participated. The data collection instruments used were questionnaires, four workshops and observations, 5-point Likert scale evaluation after every workshop and semi-structured interviews.

This chapter provides an analysis according to the study's aims and to answer the research questions. In Phase 1, I issued out Questionnaire A to the participant and it will be collected after a week, in Phase 2 four workshops will be conducted and observed, Phase 3, questionnaire B will be issued out to the participants to evaluate each workshop and lastly semi-structured interview will be conducted. I will present the data by first start with Questionnaire A, where it focuses on demographic data of the participants. The workshop, observation and evaluation on Questionnaire B data will be examined and presented together, and semi-structured interviews will be presented separately. The themes will be created and discussed based on the above data.

Figure 5:

Overview of the data collection methods for the research



Note. Created by Author

5.2 Questionnaires (appendix G)

The questionnaires were designed in the manner to collect the information relating to the gender, grades taught, number of years teaching, age and teaching qualifications of the participants. The following **Tables 4, 5, 6 and 7** demonstrate this information of the four schools.

Composition of participants from the four schools

School A

The researcher went to School A with a mix of novice and experienced teachers, resulting in a total of four participants. Three teachers were novice teachers, and all of them teaching foundation phase or primary school. The one experienced teacher was their Departmental head (DH) who was teaching grade 3. All the participants were female in this school. Two teachers had studied STEM related subjects which are Bachelor of Education in Technology and Bachelor of Education in Maths, Science and Technology. Two teachers had no qualifications on STEM related subjects. The two teachers were between 41 to 50 years and one was between 31 to 40 years and the eldest was between 51 to 50 years. The eldest participant obtained M+4 as her qualifications. M+4 means senior certificate plus four years.

Table 4

The composition of participants in school A

Participants	Gender	Teaching grade	Number of years teaching	Age	Teaching qualifications
1	Female	1	4	31-40	Bachelor of Education in Maths, Science and Technology
2	Female	3	3	41-50	Bachelor of Education in Economics Management Sciences
3	Female	2	4	41-50	Bachelor of Education in Technology
4	Female	2	26	51-60	M + 4

Note. Teacher's information from School A

School B

In School B (Table 5) below, the researcher met four participants, who were all novice teachers. During the site visit, it was observed that the experienced teachers seemed busy with departmental meetings. The school replaced the experienced teacher with a novice teacher to

make a total of four participants. Seventy-five percent of the teachers have studied the STEM subjects. One teacher had not studied a STEM related subject, the teacher studies Bachelor of Education in Languages. All four teachers were teaching from a primary school. Fifty percent of the teachers were females and another 50% were the male teachers. The age that dominated in this school is between 31 to 40 years and it consisted of 75% and one teacher was between 20 to 30 years and composed of 25 percent. The novice teachers were more into the STEM field, and 75% studied it.

Table 5

The composition of participants in School B

Participants	Gender	Teaching grade	Number of years teaching	Age	Teaching qualifications
1	Female	3	4	31-40	Bachelor of Education in Languages
2	Male	3	3	20-30	Bachelor of Education in Technology
3	Male	4	2	31-40	Bachelor of Education in Mathematics
4	Female	2	4	31-40	Bachelor of Education Honours in Natural Sciences

Note. Teacher's information from School B

School C

School C is a high school, where four teachers were available to take part in questionnaires. Two teachers were novice and the other two were experienced teachers who were the deputy principal and the departmental head for the senior phase. All these teachers participated on the questionnaires. Two teachers were females, and the other two teachers were males. One teacher from this school had specialised in a STEM-related subject, and the rest had studied the

qualifications that were different from STEM subjects. The one teacher who taught a STEM related subject had specialised with Bachelor of Education in technology. On the other hand, one educator had studied STD which is a type of Advanced Certificate in Education. Grade Eight and Nine had a mix of female and male teachers.

Table 6

The composition of participants in School C

Participants	Gender	Teaching grade	Number of years teaching	Age	Teaching qualifications
1	Female	8	21	51-60	Bachelor of Education Honours in Social Sciences
2	Male	9	8	31-40	Bachelor of Education in Technology
3	Female	9	11	31-40	Bachelor of Education in Social Sciences
4	Male	8	25	51-50	Secondary Teachers Diploma (STD)

Note. Teacher's information from School C

School D

Lastly, School D consisted of four teachers, three novice teachers, and one experienced teacher at a high school. In this school there were two males and two females as participants in this study. Grade Eight was taught by one male teacher and one female teacher, while Grade Nine was also taught by one male teacher and one female teacher. Three teachers had studied STEM

related subjects during their Bachelor of Education degree; namely Information Technology and Bachelor of Education in Technology and Bachelor of Natural Sciences. One teacher had studied subjects that are totally different from STEM subjects. The age group that dominated in this school is between 20 to 30 years of age, because they were three teachers of this age and only one teacher that was between 31 to 40 years.

Table 7

The composition of participants in school D

Participants	Gender	Teaching grade	Number of years teaching	Age	Teaching qualifications
1	Female	8	4	20-30	Bachelor of Education Information in Technology
2	Male	9	12	31-40	Bachelor of Education in Natural Sciences
3	Female	9	3	20-30	Bachelor of Education in Technology
4	Male	8	2	20-30	Bachelor of Education in isiXhosa and History

Note. Teacher's information from School D

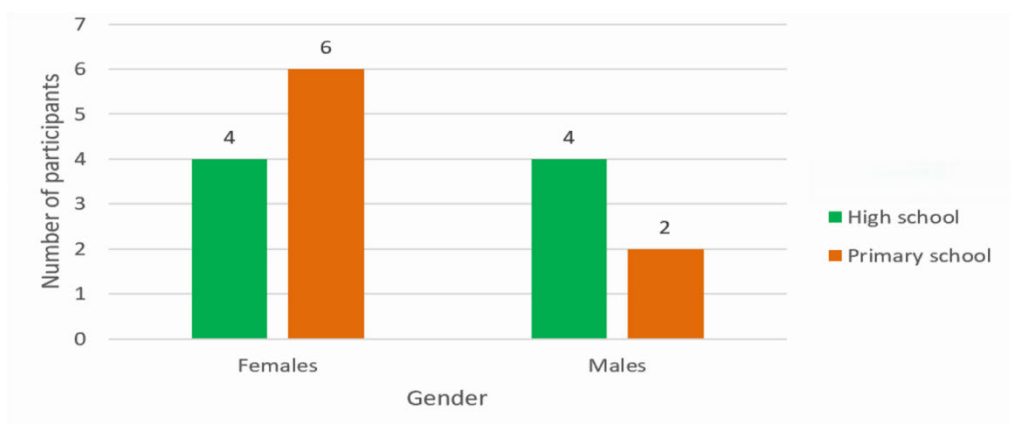
More information on participants

A. Gender

Most of the participants in these schools were the females, this research consisted of 10 females and six males (Figure 6). Hence, indicating female teachers showed much interest in studying

about coding and robotics. Most of the teachers that are teaching in primary schools are female teachers. School A consisted of only female teachers. Primary school had six female teachers and four high school teachers. A total of six male teachers participated on this research coming from both primary and secondary school. There is underrepresentation of male teachers in STEM field. In this school, there is a dominance of female teachers who are showing willing to teach this subject.

Figure 6
Participant's gender



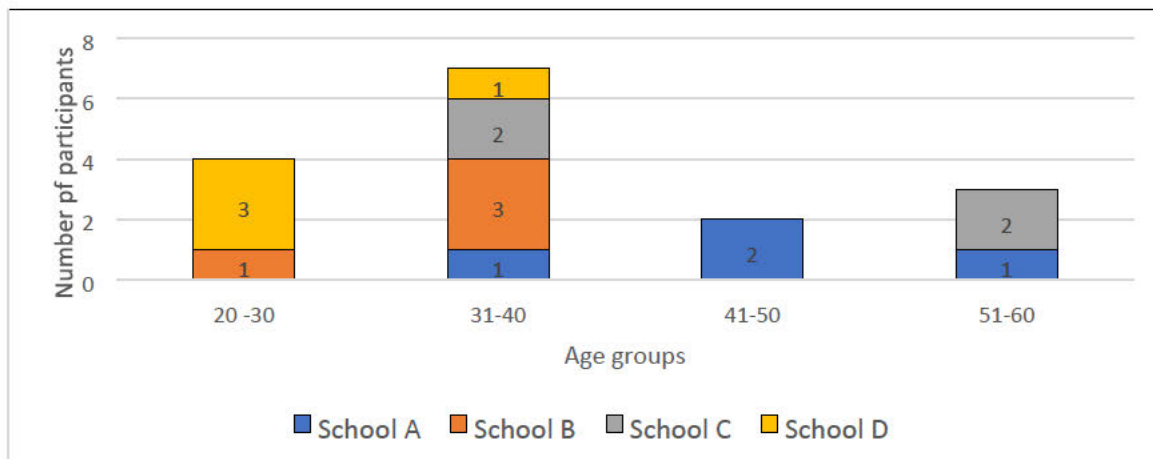
Note. Gender participants from primary and high school

B. Age

Figure 7 depicts that the most age group that appeared to be the most is between 31- 40 years. From the sixteen participants 31-40 years age group (mid age group) dominated by seven teachers. There were three older teachers who were between 51 to 60 years: two females and one male. There were four participants who were between the ages of 20 to 30 years regarded as the youngest. The graph below it clearly presents that in all four schools the age group that dominated is between 31 to 40 years and 41 to 50 years was the least.

Figure 7

Ages of the participants



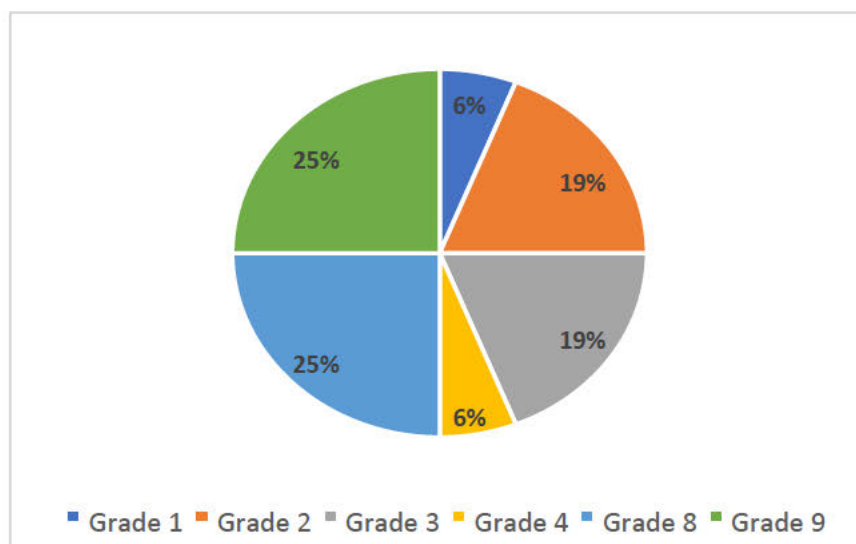
Note. Age groups of the participants

C. Grade teaching

Most of the teachers were teaching grades Eight and Nine (~25%), they were four teachers in both grades. A small percentage of teachers were teaching grades One and Four (~6%). Nineteen percent of teachers were teaching grades Three and Two. All this information is shown on the pie chart in Figure 8 below:

Figure 8

Pie chart of the grade taught by these teachers



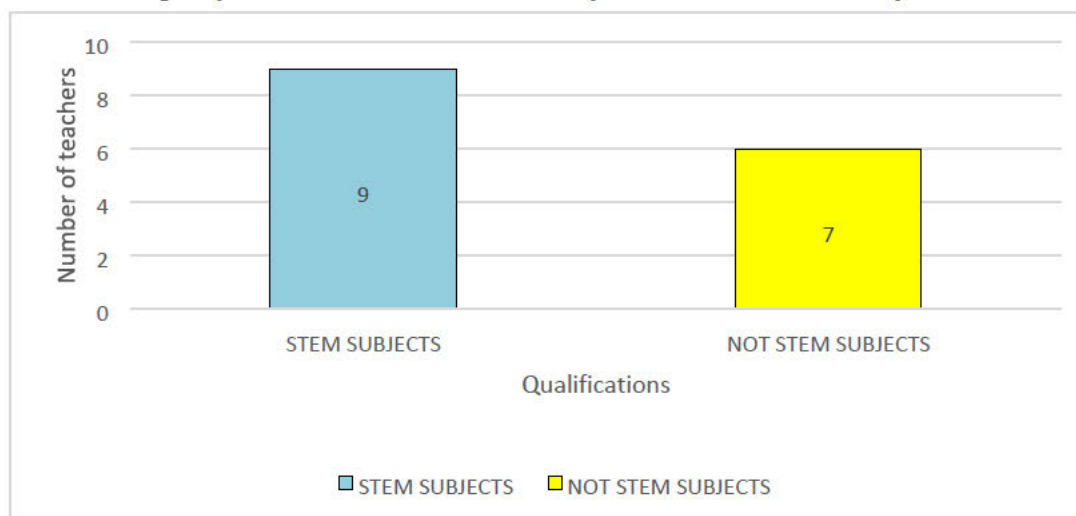
Note. Grades taught by the participants

D. Teaching qualifications

Figure 9 indicates that seven of the teachers were allocated to teach this subject, although they did not have the relevant teaching qualifications. Nine teachers have had teaching qualifications are related to STEM subjects while seven teachers had qualifications that are not related to STEM subjects. Teachers with STEM related subjects understood the terminology of coding and robotics better than other teachers without it. Throughout the 16 participants, only one teacher had formally studied Information Technology.

Figure 9

Teacher's qualifications based on STEM subjects and not STEM subjects



Note. Qualifications of the participants

5.3 Four workshops

In each workshop, there were two activities to be completed by the participants of the same school, where they were expected to work as a group. After each workshop, participants were asked to rate their activities. The rating system was in the form of Likert scale with 1- *Very difficult*, 2 – *Difficult*, 3 - *Neutral*, 4 – *Easy*, and 5- *Very easy*. These workshops were standalone work, and took place in four different schools. During these workshops, the researcher used observation schedule to monitor their work. In this section the researcher will report the workshop feedback together with the observed data.

Observation is a powerful tool for evaluating workshop effectiveness. It allows the researcher to collect direct and immediate feedback from the participants. The goal of this was to determine whether the participants were able to work as a team to solve of the problems given.

I (researcher) also monitored the time they took to complete their activities. Also, will also be able to check how much they are involved in activities.

5.3.1 Robotics skills: workshop one (appendix H)

Table 8

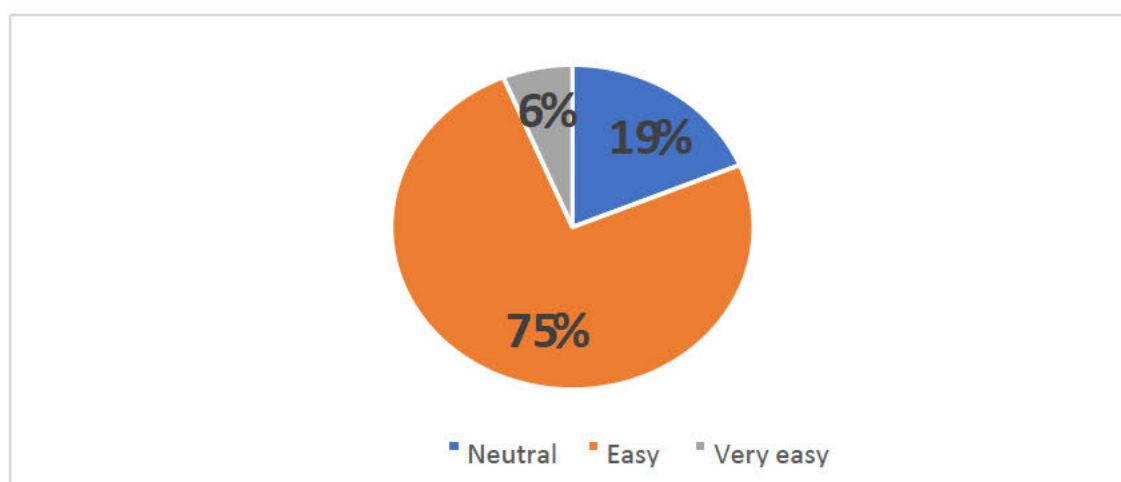
Summary of Robotics skills Workshop one

Workshop 1	Very difficult	Difficult	Neutral	Easy	Very easy	Total number
School A			2	2		4
School B				3	1	4
School C			1	3		4
School D				4		4
Total			3	12	1	16

Note. Summary evaluation of Robotics skills from Workshop One (Appendix J)

Figure 10

Observation from workshop one



Note. Observation schedule on Robotics skills: Workshop One (Appendix I)

Table 8 and Figure 7 indicate that no participants reported the activity to be very difficult or difficult. Three participants noted the activity on robotics skills to have been neutral, 12

participants found this work easy, one participant said it was very easy. Activity 1 and 2 was based on robotics skills; teachers were working as a team. In all the four school's Activity One was guided activity and the rest of the activities were unguided activities.

Workshop 1: Activity 1

In Activity 1, teachers were very attentive and asking clarities where they do not understand. They were very focused and interested in the activity. In this activity, the teachers were learning about robotic skills. The instructions were clear requiring the coders to follow instructions by counting the steps in order to find the treasure.

Workshop 1: activity 2

In Activity 2, they worked on their own, where they needed to instruct one person follow a certain sequence as to get the ball. This activity required teamwork and engagement; the elected participants dependent entirely to the teammates for their movements. All schools completed this activity early and said it was easy and straight forward. SAT refers to School A Teachers, SBT stands for School B Teachers, SCT refers to School C Teachers, and SDT stands for School D Teachers.

5.3.2 Internet and e-communication skills: Workshop Two

Table 9

Summary of Internet and e-communication skills: Workshop Two

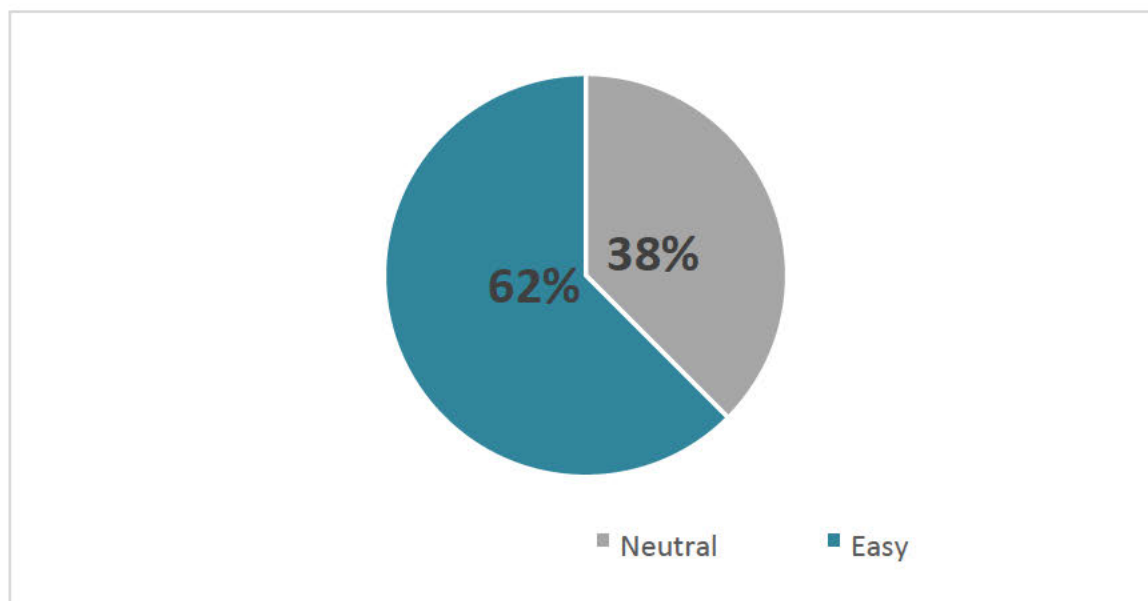
Workshop 2	Very difficult	Difficult	Neutral	Easy	Very easy	Total number
School A			3	1		4
School B			1	3		4
School C				4		4
School D			2	2		4
			6	10		16

Note. Summary on evaluation of Internet and e-communication skills: Workshop two

(Appendix M)

Figure 11

Observation from Workshop Two



Note. Observation schedule- Internet and e-communication skills: Workshop Two (Appendix L)

Table 9 and Figure 8, in Workshop Two, the activities were based on internet and e-communication skills. No participants said the activities were very difficult, difficult and very easy. Six participants noted that the activities were neutral, and ten noted that they were easy.

Workshop 2: Activity 1

On Activity 1, this activity was based on digital identities, safety on digital platforms and introduction to networks and the internet, and the use of web browsers to search for information. In Activity One, participants were required to match an icon with the correct descriptions. Participants worked together and they were allowed to use their android phones to check these icons. All the participants in different schools were highly focused on the activity. In School C, Teacher 1 was working as an expert as this teacher was guiding other teachers to complete this work.

Workshop 2: Activity 2

Table 9 and Figure 8 demonstrate that this activity was easy to many participants. Since the participants were working as a group, they managed to complete the work within the stipulated time. The participants between 20 to 30 years were dominating this activity and assisted other participants. They took 15 minutes to complete this work and they were all correct.

5.3.3 Algorithm Workshop Three (Appendix N)

Table 10

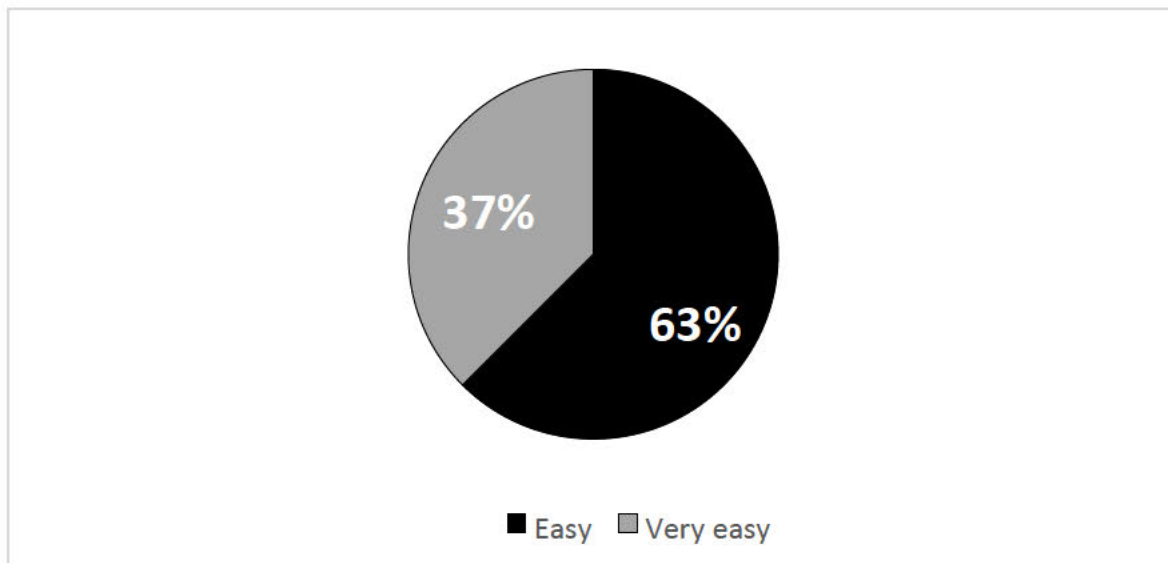
Summary of Algorithm: Workshop three

Workshop 3	Very difficult	Difficult	Neutral	Easy	Very easy	Total number
School A				4		4
School B				4		4
School C				2	2	4
School D					4	4
				10	6	16

Note. Summary on evaluation of Algorithm: Workshop Three (Appendix P)

Figure 12

Observation from Workshop Three



Note. Observation schedule on algorithm Workshop Three (Appendix O)

The Table 10 and Figure 9 algorithm required participants to follow the sets of instructions or rules to solve problems. All the participants were able to generate the intended picture. They followed the given instructions and guidelines in order to do so. In other words, they followed all the steps to achieve a desired goal.

Workshop 3: Activity 1

In this activity, the participants were still working in groups. Teamwork enabled these groups of participants to complete the activities relatively easy. If they were working as individuals, I noticed that some would struggle on completing the activities. Working in groups was highly beneficial for achieving common goals and fostering creativity, collaboration, and problem-solving. Group members brought different experiences, skills, and viewpoints, leading to more inclusive resolutions. I noticed that tasks divided among members reduce individual burdens and enhance productivity.

Workshop 3: Activity 2

This activity was based on binary, participants were required to write their names using the binary by even colouring the boxes on the provided sheet. School B asked for further clarities to complete this work. In School C, teachers were very fast to complete this work as they take 13 minutes to finish. In School A they were assisting one another to complete the work, others

were struggling but assisted by group members. Group work helped develop essential communication skills and conflict resolution skills.

5.3.4 Pattern and recognition: Workshop Four (Appendix Q)

Table 11

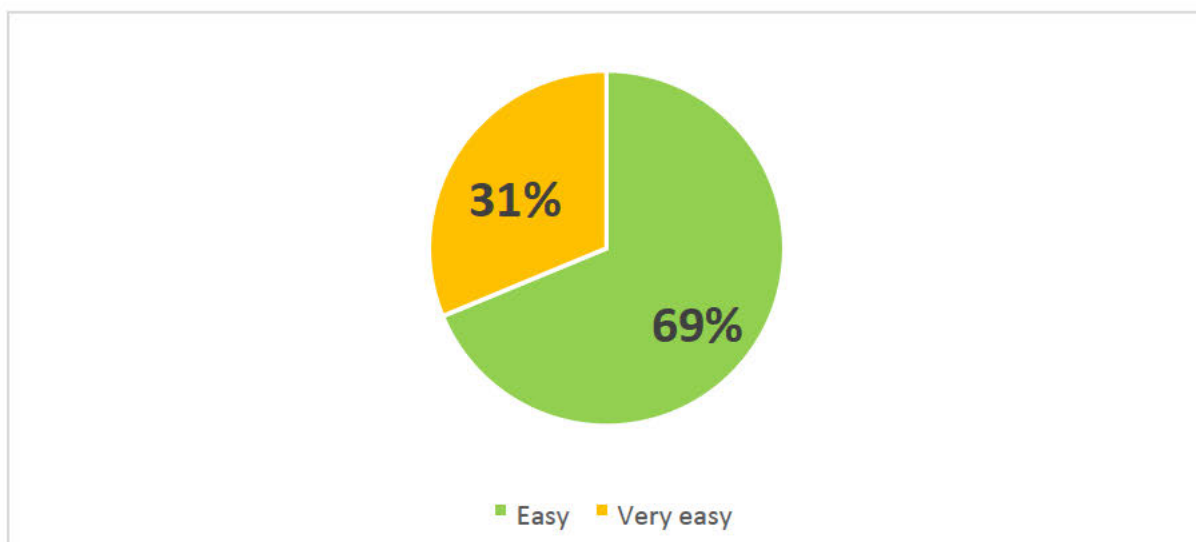
Summary on patterns and recognition: Workshop Four

Workshop 4	Very difficult	Difficult	Neutral	Easy	Very easy	Total number
School A				4		4
School B				2	2	4
School C				3	1	4
School D				2	2	4
				11	5	16

Note. Evaluation summary on patterns and recognition: Workshop Four (Appendix S)

Figure 13

Observation from Workshop 4



Note. Observation schedule Patterns and recognition: Workshop 4 (appendix R)

Table 11 and Figure 13 indicates that eleven participants found the activities easy and five said they were very easy. The two activities were based on patterns and recognition, where 68.75% of the participants said the activities on patterns and recognition were easy while the remainder of 31.25% said it was very easy.

Workshop 4: Activity 1

This activity was based on the patterns, teachers were expected to follow the given trend in order to complete the pattern. Coloured pens blue and red was provided so that the teachers can complete their work. School A was the first school to finish this work within 10 minutes, all schools were allocated a maximum of 20 minutes to complete each activity. School D was the last school to finish and they took 20 minutes. School D was a bit disordered as they were busy answering their phones during the activity time.

Figure 14

Picture of necklace from School A



Note. Crafted necklace from school A

Figure 15

Picture of necklace from School D



Note. Crafted necklace from school D

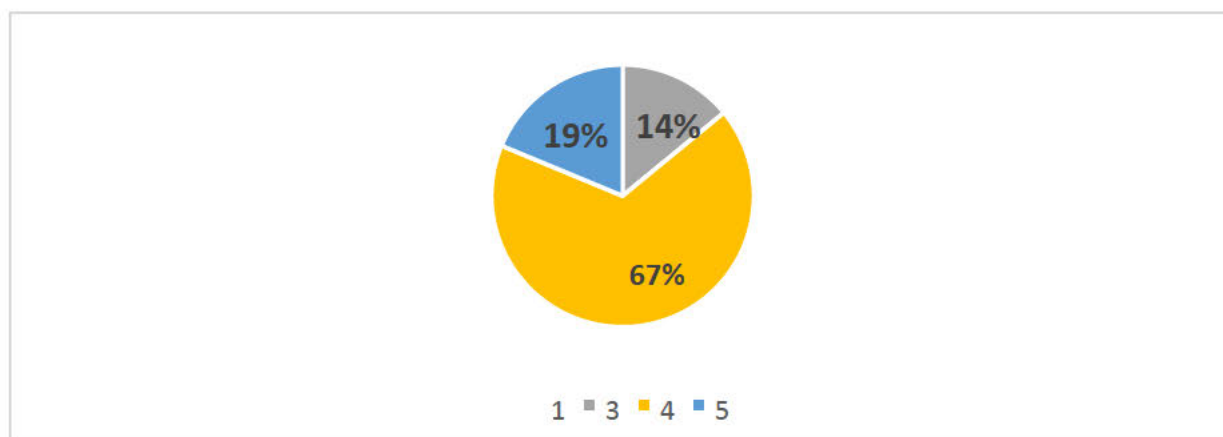
Workshop 4: Activity 2

The above pictures show the participants designing the pattern and deciding on a bead to use. Material to construct necklaces were provided by the researcher in various shapes and colours. Their bracelets were well constructed and group followed their own pattern. They showed excitement in doing these activities, noting them to be easy. Su et al. (2022) supported that

“robot education facilitates creativity and problem-solving skills” (p. 1). The participants in all schools excelled to show their creativity as groups, the following figures show their unique ways to design a bracelet.

Figure 16

Summary of ease levels over the four workshops



Note. Summary from the four workshops

Note. 1-Very difficult, 2- Difficult, 3- Neutral, 4- Easy and 5- Very easy

No activities were found very difficult or difficult by the participants in all workshops. This denotes that teacher enjoyed and mastered unplugged coding. The majority of participants about 67% said all the activities were easy, 19% said the activities were very easy and 14% said the activities were neutral.

The above pie chart on Figure 12 demonstrates that all the workshops attended by the teachers were all easy. Teachers worked in groups and showed support to one another and it was easy to finish the activities. All the four workshops were viewed as easy by the majority of the participants. Few teachers knew about unplugged coding. They enjoyed the activities and commented that the activities stimulate the mind. They proposed that government should introduced unplugged coding to all rural schools. This type of coding does not require expensive resources.

Table 12

Average level of ease across all four workshops

Workshops	1	2	3	4	5	Average
Workshop 1			3	12	1	3.88
Workshop 2			6	10		3.63
Workshop 3				10	6	4.38
Workshop 4				11	5	4.31

Note. Average level of ease from four workshops

The averages according to the workshops reflect that all teachers felt that the workshops were easy. The teachers understand coding basics through hands-on activities. They demonstrated problem-solving skills and logical reasoning. These teachers also showed creativity and innovation through non-digital means in completing the activities.

5.4 Semi-structured interviews (Appendix T)

The semi-structured interviews were captured by a smartphone audio recorder. Data was gathered, analysed, and transcribed. Transcripts were cross-checked transcripts with the original recordings to ensure accuracy. A semi-structured interview schedule had been used to guide the interview process. All participants were given informed consent forms to sign, giving the researcher had permission to audio record. There were five teachers who participated in these interviews: one teacher from School A (SAT), one teacher from School B (SBT), two teachers from School C (SCT) and one teacher from School D (SDT). These teachers from different schools will provide their insight of coding and robotics in the following research questions:

1. Have you ever seen a robot in your life? If yes, where did you see it? What were the characteristics of the robot?

Form the total of five participants, it was revealed that three teachers never saw a robot, they do not have the idea of how a robot looks like. Two participants from different school confirmed that they know the robot and they were able to give the characteristics of what it looks like. Three out of five participants said no, they never saw the robot and this explains that some of the teachers in rural schools are not exposed to technology. SAT 1 noted: *“Yes, the characteristics of the robot were to perceive the environment using sensors, perform actions enables by actuators”*.

The teachers require technological training for the 21st century. The Department of Education must provide thorough training to rural schools so that they have more knowledge about coding and robotics. There should be more initiatives for coding and robotics to empower rural schools and learners, equipping them with essential skills for the future. These programmes ought to aim to inspire teachers from rural schools to pursue STEM fields by demonstrating that they can both interact with and build robots. In addition, companies like Sasol, South 32 Robotics Academy and Future Africa's Robotics and Coding Initiative ought to be invited to visit rural schools and provide training to teachers and subject advisors on the 4th Industrial Revolution.

Adequate rural school's teacher training will empower them about the importance of technological literacy. Teachers will be equipped with computing skills that will help them in transferring the skills to the learners. Their learners will be digitally literate and better prepared to face challenges in life, knowing how to adapt to new technologies and their importance.

2. Would you like to design a robot? Why?

The majority participants (four out of five), showed interest in designing the robot, their various responses to this question outlined that these teachers have an understanding of robots, the functions and its usefulness. *SCT 1: "Yes, I would love to design a robot because I'm fascinated by technology and problem-solving, designing a robot would allow me to explore the different uses of technology"*. One teacher claimed that he would not design a robot, because they are very expensive. *SCT2: "No, because they are in nature expensive"*.

Robots encourage teachers to design, build and programme robots to solve real-world problems. *SBT1: "Yes, I would like to design one, robots are able to work for many hours without getting tired, and Robots are so fast in doing human chores"*. These robots are very important, because they encourage the learners to be creative and think critically. *SAT1: "To solve real world problems and improve efficiency"*.

In this century, teachers are encouraged to be literate about robots so that their learners can be able to analyse problems and develop innovative solutions. Robots ought to be designed in rural schools as to provide competitive educational opportunities. *SDT 1: "To advance knowledge in robots and AI"*. The educational inequalities between urban and rural schools ought to be closed. One participant explained that these resources are expensive, so it is

possible for other schools to not design them. The Department of Education ought to provide schools with necessary resources to develop these robots.

3. If you were to design a robot, what would be the characteristics of the robot you designed?

Four teachers answered to this question and these teachers clearly explain how they would design a robot, providing the features they would like to see in one. *SAT 1: "Explore environmental that are difficult or impossible for humans to access".* Most of these mentioned that they would design a robot that is able to function independently. *"SDT 1: If I were to design a robot, I would specifically design a MedBot purposely to assist in healthcare professionals with task like patient monitoring, medication reminders and vital sign tracking. A robot with an ability to navigate and perform tasks independently. It must have vital sign monitoring fall detection and environmental sensing".*

The robot ought to be able to connect to real-world scenarios and problems and also perform various tasks and projects. *SBT1: "I would design a robot that is not only intelligent and efficient but also enduring and helpful."* It should be able to serve the intended purpose, such as, to design control algorithms and choose suitable micro-controllers. The robots designed ought to ensure safety and reliability. All the robots should effectively promote education for learners. *SCT1: "the characteristics of the robot I would design would be an ability to perform tasks independently and be able to learn and adjust to situations".*

4. Would you like to take coding training?

All the five participants were interested to attend coding training. *SBT1: "Yes, I would like to take coding training".* These teachers showed eagerness to be trained for coding and one teacher mentioned that she has been attending coding training for many times. *SCT2: "Yes, although I have taken coding training in couple of times".* This one participant further emphasised that coding enhances logical thinking and problem-solving abilities. Their responses showed that these teachers were willing to improve their digital literacy skills. They were aware that coding skills tend to be in high demand.

Coding training in rural schools is important for bridging the digital divide and empowering teachers with essential skills for the future. Ideally, South Africa's and Robotics introduces learners to coding app design, using Apple's Everyone Can Code Curriculum. Teachers who attend coding training will develop critical thinking, problem-solving, and digital literacy.

These teachers will be able to prepare learners for technology-driven jobs, entrepreneurship, foster creativity, innovation, and collaboration.

5. What do you need to be able to code?

The majority teachers mentioned that computer is needed in order to code. SCT 2 wrote: *“To code you need a device network for some programmes and internet”*. They also mentioned other important skills that are part of coding like computer and logical skills. SDT 1: *“To be able to code you will need essential skills like logical thinking which is to breakdown problems into manageable parts. Be able to solve, identify and fix problems you must obviously be able to pay attention to detail in order to write accurate code. You must be patient so that you can find debugging and troubleshooting very much easy.”*

All the teachers understand what is needed in order to code. They further outlined that the person must pay attention and also the person should be patient. All teachers understood that in order to code, there should be computer availability and the person should be also connected to the internet.

Indeed, to code the teachers need laptop, desktop, or tablet, text editor, programming language like Python, JavaScript or HTML/CSS, and an internet connection. Moreover, rural schools often lack the necessary fiber-optic cables or cell towers to support reliable internet connectivity. Rural schools do not have the financial resources to invest in internet infrastructure, where rural areas are often far from urban centres, making it difficult to establish and maintain internet connections.

6. When introducing coding robots to young learners what are the challenges you encountered into the classroom?

These teachers are from four schools who tried to teach coding and robotics. These teachers encountered similar problems, in terms of inadequate teaching resources. SDT1: *“The challenges I encountered in the classroom include classroom management, ensuring learners stay focused and on task. Technical issues, some robots or devices were malfunctioning or not connecting. Different learning paces, some learners were not following others were progressing. Resources were not adequate, so few learners were accommodated at a time. Later the teaching equipment was stolen.”* Schools showed a willingness to introduce coding and robotics, but struggled due to insufficient teaching resources and high degree of burglary in schools.

Teachers in rural school faced difficulties in accessing resources, workshop, or support. Educators lack experience or training in coding and robotics. Most of the teachers have limited exposure to technology. In these schools, teachers are still using chalkboard and chalk to facilitate teaching and learning. *SCT 1: "It was difficult for me to understand some concepts and there were limited teaching resources"*. Technological infrastructure is available but in limited numbers, laptops are the priority to be used by admin clerks.

7. Are you able to integrate coding and robotics to existing curriculum?

All participants responded that they were not able to integrate coding and robotics to existing curriculum. All the participants complained about the issue of not having resources to teach this subject. These teachers were unable to design coding and robotics activities that apply to real-world problems, promoting critical thinking and creativity. SCT2 commented: *"I won't be able to answer that because we couldn't continue with coding and robotics in our school. In our school we couldn't introduce coding and robotics because we had no resources, I am not sure if we were able to integrate with existing curriculum". "Coding and robotics are in my blood, but the problem I experienced; resources were not available in this school"*.

These teachers are failing to use code to create interactive stories that promote literacy skills. By integrating coding and robotics into existing curricula, educators would be able to make learning more interactive and fun. Teachers are able to encourage critical thinking, creativity and collaboration. Incorporating coding and robotics enable teachers to use robots to collect data, conduct experiments, or demonstrate scientific principles. Learners will be prepared with important skills for the future. This means that these four schools I researched are missing a lot by not integrating coding and robotics to the curriculum.

8. What do you do to deal with technical issues like hardware malfunctions to software glitches?

Software glitches can be frustrating, but understanding their causes and knowing how to troubleshoot can help resolve issues efficiently. The following are the reasons for the software glitches: incompatible software versions, low memory processing power, conflicting software, corrupted files and malicious software. The software will be unresponsive or shut down unexpectedly when it has technical issues.

Four teachers said they would seek assistance from other people when they encounter software glitches. *SBT1: "I would report to IT committee of the school"*. One teacher said she had studied information Technology so it would be easy for her to solve any software glitches. *SCT1: "I would ask assistance from my colleagues"*. Technical support can come from colleagues in school level who got expertise on technology. *SAT1: "I would report to IT technician of the district department of education"*. Effective technical support can minimize downtime and ensure a smooth learning experience.

9. What are the challenges that schools experience when integrating technology?

These schools encountered various challenges when integrating technology, in most schools the challenges were limited access or no access to technology, limited devices and access to internet. *SAT1: "Teachers that are not adequately trained to integrate technology"*. Teacher from one school mentioned that they couldn't continue with coding and robotics as a subject due to no resources. Lack of proper digital infrastructure, such as computers, printers, and appropriate educational software, hinders effective technology integration. *SBT1: "These are the challenges that my school experiences when integrating technology: infrastructure limitations, outdated hardware and insufficient internet connectivity"*. Furthermore, there is limited access to high quality digital learning resources. *SDT 1: "Unequal access to devices and internet"*.

Many schools struggle with limited budgets, making it difficult to purchase necessary resources for programming, software and reliable internet access. Teachers lack sufficient training in how to integrate technology into their teaching practices. Inadequate infrastructure makes it difficult to implement digital learning strategies and can lead to other school not integrating coding and robotics. These issues hinder effective technology integration and limit the potential benefits of digital literacy

10. Are coding robots beneficial for young children's learning?

All the teachers agreed that coding and robotics are beneficial to the learners. *SDT1: "Yes, coding robots can be highly beneficial for young learners' learning offering development of problem- solving skills which encourages critical thinking and logical reasoning. It promotes teamwork and communication"*. Coding and robotics equip learners to have problem solving skills in difficult situations. *SBT1: "Yes, it increases problem solving skills"*.

There are certain skills like communication, creative problem-solving that learners get from coding and robotics. *SCT2: "Coding are beneficial for young children's learning since a world is revolving and we are in fourth industrial revolution where everything now is technical based"*. Also, mentioned that the century that we are currently living in requires the above-mentioned skills *SBT1: "Yes, it increases problem solving skills"*. It enhances creativity to design and build robots, promoting creativity and innovation. *SCT2: "It promotes learners' creativity"*.

Coding and robots can be highly beneficial to learners in various ways: through enabling learners to programming and automation, learners can work in teams to design and build and program robots, improve logical reasoning and sequence planning. It is beneficial for learners to study coding and robotics as to meet the skills of this century. *SAT 1: "Yes, coding robots introduce learners to basic programming skills"*. Learners will be able to get employment opportunities in technology driven industries.

11. What are the challenges of robotics in education?

Teachers mentioned the issues of teaching resources that are limited or not available. Other, mentioned that the department of education is not supplying enough teaching resources. *SdT1: "Robotics in education can face a lot of challenges such as cost, robotics equipment and software can be very expensive. Lack of proper teacher training is another challenge"*.

Teachers are complaining that they did not receive adequate training for teaching coding and robotics. *SCT1: "Resources to teach robotics are not adequately supplied by the department of education. Teachers training that was offered was not enough, it only took five days"*. There is an outcry from the teachers that the training was very short, one teacher mentioned that it only took five days. *SAT1: "Shortages of teaching resources and lack of teacher training"*.

Robots kits and equipment can be expensive, making it inaccessible to some schools. *SBT1: "Robotics kits and equipment are very expensive and my school is not able to buy these kits"*. Schools lack necessary infrastructure such as space or internet connectivity. This equipment can malfunction or require technical support. Difficult to integrate coding and robotics to curriculum due to above factors.

12. What are the challenges and barriers of integrating technology?

The teachers outlined many challenges and barriers of integrating technology in the respective schools. SAT1: *“Limited teacher training and support to integrate technology”*. In many schools the major problem is the issue of resources that are not available, the issue of internet connectivity. SDT1: *“Unequal access to technology and internet connection”*. These participants felt they were disadvantaged because of lacking proper infrastructure.

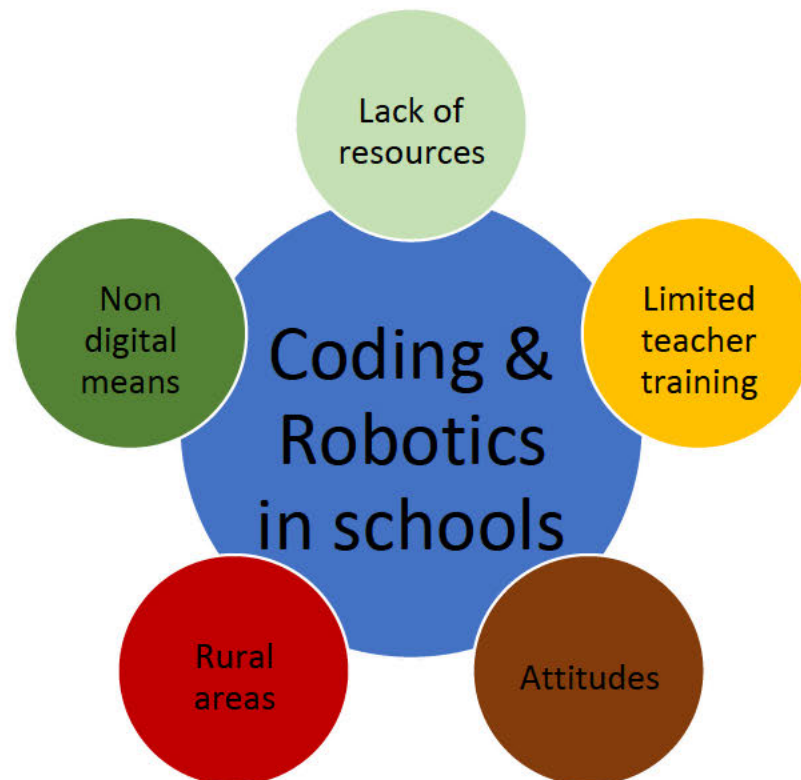
One teacher mentioned that it’s still difficult for the rural schools to compete with urban schools because they still lack basic infrastructure like water and electricity SCT2: *“Challenges could be the lack of internet connection, resources, we do not have infrastructure, no resources that are technologically based, I do not see us having those resources now because we still need other things (basic infrastructure: water and electricity) that have not been met compared to cities or urban areas, in rural areas we are also struggling to internet connection”*. If these challenges and barriers of integrating technology can be resolved it would be possible to teach coding and robotics.

5.5 Themes created from data collected

To analyse the data, I chose thematic data analysis, thematic analysis is a flexible and systematic way of making sense of qualitative data. The thematic analysis involves identifying, analysing and reporting patterns (themes) within the data, with the aim of capturing something important in relation to the research questions (Proudfoot, 2023). I firstly, analyse the data by reading for four times the transcripts, the data was coded by highlighting text to generate codes. The researcher organised the data into common meanings and codes were arranged into themes. The data collection instruments used were questionnaires, four workshops and observations, 5point Likert scale evaluation after every workshop and semi-structured interviews. From the data collected the following themes emerged- Theme 1: Lack of resources, Theme 2: Limited teacher training, Theme 3: Attitudes, Them 4: Rural issues and Theme 5: Non-digital means

Figure 17

Presentation of five themes



Note. Created by Author

5.5.1 Lack of resources

One of the most substantial challenges of introducing coding and robotics in South African schools is access to resources. There are schools that lack basic computer equipment, which makes it difficult to implement coding and robotics programmes. Schools with limited resources often find it difficult to provide excellence education. The infrastructural deficiency limits the applied learning component with digital tools integral to Coding and Robotics. The African continent presents a diverse landscape, with varying levels of technological adoption, where, while some nations have made significant strides in embracing robotics, others face challenges related to infrastructure, education, and economic constraints (Okare et al., 2025).

Improving infrastructure facilities in schools is crucial to the implementation of coding and robotics subjects in South African schools. According to Macron (2025), the cost of robotics

tools are not the only financial challenge schools face, where integrating robotics into the curriculum also requires ongoing funding for maintenance, teacher professional development, and access to external experts who can support robotics initiatives in schools. Schools' ought to devise a means and obtain the required material to teach this subject.

Inadequate resources are a general problem in most schools in rural areas. SCT2 said: *"Challenges could be the lack of internet connection, resources, we do not have infrastructure, no resources that are technologically based"*. Schools in rural are always under sourced schools and are completed different from urban schools. Schools lack digital tools and that impact negatively the quality of education delivered. Without these tools, teachers cannot integrate technology. In most schools, there are no computers to be used by learners, where the few laptops that are available are used by the teachers and clerks. In Questionnaire A 16 participants outlined a problem with adequate resources in their schools.

In School A, laptops were provided by the Department of Basic Education, however, due to high crime rate, these laptops were stolen. Most of the teachers did not have computer-related subjects as their qualifications to teach coding and robotics. These teachers were working very hard in preparing for their lessons. Other teachers said they were allocated to this subject so that they could be a teacher in front of the learner. Teachers worked in collaboration to come up with the lesson plans. They noted that videos from YouTube assisted them to formulate the lesson plans. These videos were useful because they show step-by-step in teaching activities.

All four participating schools are located in rural areas without proper and reliable internet connectivity. Internet connectivity is noted as one of the tools crucial to helping rural areas to overcome geographic isolation, to promoting access to resources and opportunities, and to social interaction and community engagement, increasing the possibilities of poor performance and increasing high attrition rate and economic and social development. The unequal access to internet, especially broadband connections and devices such computers, laptops, tablets and phones, persists in schools especially the rural areas (Ahiaku, 2025).

These schools lack adequate infrastructure, such as access to the internet and computers, which is necessary to support the teaching of coding and robotics. Many schools are located in remote areas, with poor access to network connectivity and electricity, making it difficult for teachers to interact with technology effectively. In these research sites, there are areas within the school property that are well known for not having network or signal. If the person wants to go to the

internet, that particular person will be forced to search for the area in which is visibility of signal or network.

5.5.2 Limited teacher training

Lack of training in robotics, teachers also face challenges when attempting to integrate robotics into their existing curricula. Without adequate teacher training, teachers are left to struggle with the unfamiliarity of teaching robotics. According to Macron (2025), effective robotics education requires teachers to not only understand the technical aspects of the subject, but also to be capable of fostering creativity, collaboration, and problem-solving skills among students. Without proper training, teachers are unlikely to develop these essential skills, thus hindering the successful integration of robotics into the classroom.

According to Dagienė et al. (2022). “training in primary teacher education programs is limited mostly to digital literacy and dominates among all countries, even in those who have introduced informatics related curriculum in primary education, or where such curriculum is being developed” (p.12). A significant barrier to the introduction of robotics education in primary and high schools is the lack of teacher preparation and professional development in the field of robotics. Teachers in early education are often trained in traditional subjects, such as geography, social studies, physical sciences and history, but many have limited experience with robotics or related STEM topics (Macron, 2025).

Most of the teachers were exposed to limited training. These teachers were not confident to teach coding and robotics. In some schools, teachers did not teach this subject as the majority of the teachers were not ready. Nevertheless, teachers taught this subject although they were not that ready. Out of 16 participants seven teachers had qualifications unrelated STEM subjects and nine teacher had STEM-related qualifications. They taught the learners some coding and robotics basic skills. Limited training resulted in some schools avoiding this subject altogether.

Teachers in these four schools outlined that there is the lack of adequate teacher training programmes that equip them with the expertise needed to teach coding and robotics. They emphasised that there is a need for specialised training programmes that would equip teachers with knowledge to teach coding and robotics in a comprehensive and engaging manner. Participant in school A said they training that was provided to them was too short, taking only

a week. Some of the teachers were not trained in these subjects and may not feel confident enough to teach them.

Inadequate training is an important determinant for learners' success in schools is the presence of adequate training, to produce competent teachers for quality teaching. Providing teachers with training, mentorship, and resources can help them improve their skills and knowledge, resulting in better educational outcomes for students (Wood, 2023). Knowledgeable teachers are distinguished by a set of professional features that makes them suitable and competent for the teaching profession, which are acquired through intensive training. Inadequate training results in incompetence, as the inability of the teacher to effectively demonstrate the pedagogic content knowledge of their subject results in learners not learning optimally as a result of poor-quality teaching (Shikalepo, 2020).

Macron (2025) supports that in order to overcome barriers to introducing Robotics Education in schools, robotics training programmes for teachers ought to be structured to provide a range of support, from introductory courses for beginners to more advanced workshops for those already familiar with the basics of robotics. The importance of continuous professional development, where teachers can build upon their skills and keep up with the rapidly evolving field of robotics technology. Providing opportunities for hands-on experience with robotics kits is essential, as teachers who have actively engaged with the technology are more likely to feel comfortable using it in the classroom.

5.5.3 Attitudes

Most teachers showed a positive attitude towards Coding and Robotics, which included effective communication, professional competence, and individual support are essential aspects of positive teacher attitudes. Teacher attitudes play an important role in the educational environment and can significantly impact the learners. Teacher attitudes can influence learners' attitudes and behaviours, affecting their long-term success. On the four workshops conducted the teachers demonstrated a positive attitude as they were assisting one another to complete the activities on unplugged coding.

Most studies in the literature concluded that teacher confidence increased with increased familiarity with coding and robotics and increased even more once teachers applied what they learned and applied coding and robotics in their real-life classrooms (Boz and Allexsaht-

Snider, 2022). Researchers propose that it is important to encourage teachers to place the technical and pedagogical knowledge they have acquired within a training programme into practice (Schina et al., 2021).

5.5.4 Rural issues

According to Maximova et al. (2021), for rural areas, the fourth industrial revolution has caused even more digital inequality, where it proves crucial to bring modern technology into remote educational practices. The schools visited face challenges like significant geographical distances, and low socio-economic status, which affect educational quality, such as inadequate infrastructure, lack of trained teachers, limited funding, low level of awareness concerning the benefits of modern technology, and limited educational offerings.

A major reason for lack of resources is that rural areas struggle to maintain the pace at which digital connectivity grows, for example, internet and broadband infrastructures are hard to penetrate in these communities. Other reasons include that most people in these communities are not educated, and find it hard to acquire IT skills, where mobile devices and other technology-enabled devices may be too expensive to afford, due to the low income (Aruleba et al., 2022)

Researchers have also identified a particular characteristic of rural schools that can positively impact teacher staffing and retention the strength of community ties. Teachers often stay in rural schools, primarily on the strength of relationships, including those with students, colleagues and administrators, as well as community members (Ingersoll et al., 2023). Rural schools need to be provided with necessary teaching resources that match the current century. These school need proper teaching resources as to be able to produce learners that will be competitive in the workplace.

Public schools in rural areas are categorised by various factors that negatively impact on the provision of quality education. Rural areas are generally remote, and relatively underdeveloped. Due to financial constraints, provincial governments are unable to provide rural schools with the necessary financial support to contribute to learners being provided with quality education. *SCT2: “Lot of learners did not have devices that is why we couldn’t continue with it, no resources.* Moreover, educational authorities cannot provide schools with much needed physical and human resources, which places a severe burden on parents who are

required to supply their children with necessities such as stationery and cleaning materials (Du Plessis et al., 2019).

5.5.5 Non-digital means

The school that the researcher visited are no longer teaching coding and robotics. Two primary schools began to introduce this subject, but had discontinued it due to various obstacles. The secondary school had not attempted to introduce this subject, as there were no facilities to implement it. Teachers are willing to teach this subject, but due to the challenges such as a lack of availability of resources, they were unable to teach it. I propose that these schools ought to opt for non-digital means, or unplugged coding.

The visited school were very happy to hear about unplugged coding, which refers to teaching coding concepts without using digital devices. The workshop conducted was based on unplugged coding, robotics skills, internet and e-communication skills, algorithm and pattern recognition. The participants worked in groups to do the activities and in evaluation they said the activities were easy. With the workshops the researcher educated the participants about unplugged coding, and how the teachers can develop these activities. Based on the four evaluations on Questionnaire B, a majority of the participants noted that the activities were easy.

Unplugged coding is the game-based learning environment has been integrated in various unplugged coding activities, where the purpose is mainly for entertainment, while more collaborative learning can in fact be leveraged by this playful setting. In addition, little attempt has been made to convey to effectiveness of unplugged activities in terms of learning achievement, students' perceptions towards their ability to learn about computer programming and computer science, and their perceptions towards unplugged coding activities (Threekunprapa et al., 2020).

Unplugged coding activities had a positive effect on the improvement of computation thinking skills of learners. The findings reveal that learners usually show high levels of motivation and class participation in unplugged coding activities (Tonbuloglu et al., 2019). Vieira et al. (2023) support that unplugged activities have become popular due to their low-cost approach in helping learners understand computer science concepts and grasp computation thinking without using computers.

5.6 Conclusion

This chapter sought to answer the research questions by analysing the data collected through qualitative data tools. The data were collected through the use of questionnaires, four workshops on different topics and observations schedules, Likert scale questionnaires, and semi-structured interviews. Through the use of various data collection, the researcher managed to collect rich information direct from the participants. The five themes were created based on the data collection methods above. These themes outlined clearly the challenges these participants experienced. It is evidently stated that in rural schools' participants are struggling, due to improper or unavailable teaching resources to integrate technology.

CHAPTER SIX: DISCUSSION

6.1 Introduction

The previous chapter revealed the findings from all the qualitative methods executed in order to gather the information. This research emerged from the DBE pilot initiative of coding and robotics in a number of rural schools. For this reason, the purpose of the research was to explore the experiences of teachers in teaching coding and robotics. The researcher used cognitive load and social constructivism to understand and make predictions about future events or behaviours. This chapter presents the summarised findings of the qualitative, implications and conclusion of a case study of teaching coding and robotics in rural schools.

Cognitive load theory may provide a way to optimise cognitive processing, by drawing on the collective working memory in situations where task is beyond the capacity of the individual's working memory (Looker, 2021). Constructivism emphasises the role of social learning and collaboration, as knowledge is constructed through interaction with peers and facilitators (Ming et al., 2025). Jardinez and Natividad (2024) explain that "social constructivism is an educational theory that suggests learning is facilitated by social interaction and assistance from others, particularly within a group setting" (p.60). According to this theory, educators are advised to work in groups as to improve productivity, foster creativity, and focus on their strengths and share workload. Findings from the research conducted bolster with cognitive load and social constructivism. These theories emphasise that the teachers will be of good use to breakdown complex tasks into smaller, manageable portions, and provide support as needed.

The discussion will focus on the following three research questions.

6.2 Discussion

4. 1. What are the experiences faced by teachers in rural school teaching coding and robotics?

The study allowed the researcher to identify any uniqueness, and the way in which these experiences influence teacher pedagogical practices. The findings are contradictory to intrinsic load and social constructivism theory in teaching robotics in rural schools, as there was no equal access to resources, and inadequate teacher support. Limited to robotics equipment and internet hindered collaborative learning. Teachers were unable to engage with complex concepts, as they lacked a deeper understanding of coding and robotics. In the interviews and

questionnaires, I conducted with the participants, it was found that these schools lack technological resources. The researcher came to the conclusion that teachers required additional training in order to effectively teach robotics and manage intrinsic load. These teachers have limited exposure to robotics and programming concepts, increasing intrinsic load. De Jager, 2025 outlined that “studies conducted on educator training globally have revealed that most educators have not been effectively trained to teach coding and robotics” (p.3). Educators need effective training to change their teaching and learning methodology and integrate technology skills when teaching STEM.

Ineffective instructional materials increased extraneous load. Extraneous load involves teachers needing to use clear and concise language, avoid unnecessary information and provide platform to support learners. Technical problems, unavailability of teaching resources, and limited funding for technology for coding and robotics distracted the learning. These schools struggle with inadequate technological resources, including internet connectivity, and functional digital tools. This led to extraneous load on teachers, which impacted negatively in the teaching of coding and robotics.

From the total of sixteen teachers who participated from questionnaires, workshops and five participants from semi-structured interviews, it was concluded that some of the rural schools are faced with common challenges in implementing coding and robotics. The DBE piloting of coding and robotics across Grades R-9 hinges not only on the infrastructure and curriculum design, but also on the training and assistance provided to the teachers (Tshidi et al., 2024).

The findings of the study revealed that the four schools investigated are not ready to teach coding and robotics. According to Vinod (2025) “a major practical barrier in India is the lack of sufficient computing devices and infrastructure in schools, especially outside of well-funded urban institutions” (P.109). The infrastructural deficiency limits the hands-on learning component with digital tools integral to coding and robotics (Tshidi et al., 2024). Teachers are not adequately equipped to teach this subject in rural schools. A majority of teachers considered the teacher training offered by the DBE to be insufficient. As a result, many teachers were not sufficiently confident to stand in front the learner and teach this subject. According to Mhlongo (2025) “many teachers may not have received coding and robotics instruction during their teacher training programmes, leaving them feeling inadequately equipped to teach these new subjects” (p.2).

Moreover, the integrating of coding and robotics into the curriculum poses challenges, including aligning activities with learning objectives, providing educator training, managing time constraints, addressing resource limitations, ensuring equitable student access, adapting the curriculum, developing appropriate assessments, navigating technological advancements, promoting interdisciplinary collaboration, and overcoming resistance to change (Phokoye et al., 2024). This shows that teachers have limited memory capacity, which can impact teaching, where as a result, proper and adequate training is required.

It was expressed by teachers that coding and robotics in rural schools is impossible, due to a lack of basic resources. They stopped teaching coding and robotics in 2024, due to high degree of burglary. Moreover, rural schools do not have proper technological infrastructure to integrate this subject. The development of the proposed curriculum and content for coding and robotics, however, require a vast number of resources, and skips out on the importance of learners developing underlining skills as needed pre-knowledge (Prinsloo, 2024).

2. How does teaching coding and robotics impact rural schools?

This second question explored how teaching coding and robotics impact rural schools. This allowed the researcher to examine the effects on student learning outcomes, engagement, and interest in coding and robotics. Coding and robotics was introduced in order to improve the quality of learning in rural schools. The Department of Basic Education wanted to create a competitive education, ensuring that all learners are equipped with 21st century skills. Qin et al (2025) support that “rural schools face significant challenges in these two areas, with shortages of both hardware and software resources and fewer high-quality teachers” (p5). It was found that schools participated in this research are no longer offering this subject in schools, due to poor teacher training, and limited technological resources.

South Africa is a developing country, which requires it to guard against being left behind in the 4IR. One way to address this is to introduce coding and robotics in the country’s primary schools. A major challenge in doing this, is the fact that the enormous majority of schools in the country do not have computer labs (Greyling, 2023). In Georgia, and in several other countries, STEM educational resources are often outdated, or not well adapted to the local context (Bitsadze, et al., 2025). Due to the lack of teaching resources some of the rural schools are not teaching coding and robotics. Some schools started to introduce it, but failed, due to

many challenges, such as limited infrastructure, poor teacher training, and a high degree of burglary.

It is discovered that these schools try to incorporate coding and robotics activities into their own classrooms but struggled. Cognitive load theory requires proper design of instructional materials, including proper resources and training programmes. Many primary schools in rural areas have not introduced coding and robotics to learners, where they complain about the unavailability of teaching resources. The development of the proposed curriculum and content for coding and robotics, however, requires a huge number of resources and skips out on the importance of learners developing underlining skills as needed pre-knowledge (Prinsloo, 2024). Teachers are aware that the introduction of this subject to learners will be advantageous to them. It is suggested that schools should have physical and technological equipment in order to teach such applications to learners in a learning environment across many classes and learners should have access to a coding and robotics (Gorrah, 2022).

3. What are the strategies and challenges involved in teaching Coding and Robotics through a non-digital medium in rural schools?

This question allowed the researcher to gain insight into what the implications for curriculum design and instructional methods might be. It was found that many teachers remain somewhat uninformed about unplugged coding, since teachers were not familiar with it and its application, the researcher organised workshops. The four workshops that were conducted by the researcher specifically focused on unplugged coding activities. The researcher breaks down complex tasks into smaller manageable portions (robotic skills, internet and e-communication, algorithm and patterns and recognitions), so that teachers can understand. The researcher used both intrinsic load theory and social constructivism in ensuring that the teachers understand unplugged coding activities, where these teachers were working in collaborations in order to promote germane load and social constructivism.

Coding is typically taught through both plugged activities, involving computer implementation, and unplugged activities are conducted without the aid of computers. The unplugged approach is particularly valuable in environment lacking technological infrastructure, such as disadvantaged school and rural schools (Olivier et al., 2024). In the absence of proper

machines for teaching coding and robotics unplugged coding should be the solution to these schools.

A majority of the teachers were unaware of unplugged coding. Through the four workshops, I organised in four different school teachers showed interest and willingness to study it. Lee et al., (2025) noted that “countries can introduce digital skills education early and effectively with minimal infrastructure by focusing on clear learning objectives and providing unplugged activities and then progressively build skills over time” (p.54). These teachers were working in groups, and were engaging in problem-solving activities that promote deep understanding and learning (germane load and social constructivism).

Social constructivism is a learning theory that substantiates knowledge as constructed through social interactions and experiences implementing coding and robotics requires the teachers to work in collaborations as to offer assistance to one another. The teachers performed very well on activities that were part of these workshops. The key takeaway in this regard is that unplugged approaches may be less intimidating to teachers without a background in programming, where they require to avoid the high costs of teaching coding (Huang et al., 2021).

Existing literature agrees with the finding that the reluctance of many teachers in taking on this new challenge for which they have not been prepared, accompanied by the lack of available teaching materials that respond to different educational contexts, increasing the digital divide and allowing educational robotics to be accessible only to a few privileged children, while the majority do not enjoy similar opportunities (Castro et al., 2022). This extraneous load towards teachers can result in poor implementation or teachers not teaching coding and robotics Govindarajan (2022) supports that “studies show that teachers need more training on how to incorporate coding technologies in their instruction” (p.26). It was found that some of teachers have had teaching qualifications related to STEM subjects and tried to teach coding and robotics. Results showed that it is difficult for the inexperienced teachers to do so.

The positive attitudes, coupled with a perceived need for more knowledge, demonstrates that teachers view coding and robotics subjects as essential, and the demand for more knowledge in the subjects also highlights the economic benefits of these skills (Mhlongo, 2025). Accessibility to coding and robotics will enable learners to adopt the necessary skill and

knowledge currently demanded. In this century, learners are advised to familiarise themselves with developments in the latest technology. The introduction of robotics and coding in schools will enhance the ability to generate unique and useful ideas in learners as a crucial challenge for 21st-century problem-solving (Letsoalo et al., 2022).

The workshops were in line with extraneous load and social constructivism, where teachers emphasised hands-on, creative problem-solving and learning activities, providing participants with an engaging and collaborative environment. It is suggested that a hands-on approach be used where educators apply in practice both technical and pedagogical knowledge that they have acquired during the training programme. Some of the teachers have little knowledge that they received from limited training, however, there remain no resources in schools. When it comes to Africa, the discourse on the 4IR centres on the opportunities presented by the introduction of digital technology, although increasingly analysis points to the constraints in its implementation, such as poor infrastructure, shortfalls in skills and education, and limited investment in research and development (Masters, 2021).

This social constructivist highlights the learners' autonomy, reflective thinking, problem solving, collaborative learning, scaffolding, as well as discussion and debates as the major learning principles in education. Cognitive load theory suggests that learners (teachers in this study) have limited mental memory resources, and that excessive cognitive load can hinder learning. In this research, teachers are regarded as learners of coding and robotics; they share their information in order to be able to teach this new subject. Germane load and social constructivism have allowed teachers to engage actively with the material, and make connections to prior knowledge.

Cognitive load theory effects optimise working memory load to facilitate the accumulation of knowledge held in long-term memory (Sweller, 2024). Policy implications in many countries have implemented educational policies that incorporate digital technologies into rural education to fulfil constitutional rights and international obligations so as to ensure that all students have equal access to learning and development opportunities (Castro et al., 2022). In South Africa, the Department of Basic Education mandates computer labs and internet access for IT classes. However, many public schools, particularly in rural and historically disadvantaged areas, still lack the necessary infrastructure. This digital divide restricts learners' access to computers and hampers their ability to acquire basic programming skills.

The researcher gathered five themes, namely: lack of resources, limited teacher training, attitudes, rural areas, and non-digital means. These themes indicated the various experiences, perceptions and challenges faced by teachers who endeavour to introduce coding and robotics. Almost all the participants understood the importance of introducing learners to the skills that are demanded by the 21st century. They showed a positive attitude towards learning and teaching this subject to the learners. If the government can intervene throughout all rural schools by providing sufficient resources, adequate teacher training, and basic infrastructure, it would indeed be possible to teach this subject.

Teachers' motivating styles characterised by autonomy support and structure were also associated with reduced extraneous and intrinsic cognitive load, as well as motivation and engagement. By using load-reducing strategies and a motivating style characterised by structure and autonomy support, teachers are able to reduce students' cognitive load and improve their self-regulated motivation, engagement, and achievement (Evans, 2024). Understanding all the types of cognitive load, teachers can create learning experiences that minimise intrinsic load and optimise germane load-deep processing and meaningful learning, leading to more effective learning outcomes.

The implementation of coding and robotics require the educators to gain adequate knowledge that is created and shaped through social interactions language, and proper technological infrastructure. Learning occurs through collaborations with other teachers with different experiences. Teachers can use collaborative learning strategies, such as group work, discussions and peer feedback, to promote social interaction and knowledge construction. Group work promotes opportunities for teachers to learn from one another, share experiences and develop social skills. Through these interactions teachers will gain confidence and appropriate skills to teach coding and robotics.

6.3 Recommendations

As robotics continues to evolve, higher education institutions have a unique opportunity to embrace this transformative technology and revolutionise the way knowledge is imparted (Phokoye et al., 2024). As the incorporation of robotics into higher education gains recognition, certain challenges and considerations emerge (Phokoye et al., 2024). The Department of Basic Education ought to develop and implement comprehensive, ongoing professional development programmes for teachers, focusing on building technological competencies, providing pedagogical training in coding and robotics, and addressing the specific challenges identified (Mhlongo, 2025). Recommendations for all teachers in South Africa that are interested and struggling to introduce coding and robotics are detailed in the following section.

Professional Development

According to Phokoye et al., (2024) unpacked that "by leveraging robotics technology, higher education institutions can provide immersive and interactive learning experiences, enabling students to engage with concepts in a hands-on and dynamic manner" (p.2). Teachers play a critical role in preparing learners for the future, and this is especially true when it comes to coding and robotics. Training coding and robotics ensure technical and pedagogical knowledge is connected and applied to real-life practices, where it is necessary to split trainees in to basic and beginner classes, and sub-divide them in pairs where they can work collaboratively and interactively in completing their coding and robots. It is also necessary to clarify the advantages and disadvantages of robotics in society, create fun activities during the training, and ensure sufficient support is available after training to assist those still not at ease with coding a robot (De Jager, 2023).

Schools are implementing the development of coding and robotics skills in curricula, but teachers are not effectively trained for teaching these skills (De Jager, 2023). To address the limited teacher training, several programmes have been put in place to train and support teachers in South African schools. The government ought to expedite and proliferate the training of teachers in rural schools and there are organisations that offer training and support for teachers in South African schools. Providing ongoing training and support for teachers can help them effectively integrate coding and robotics.

National educational programs should be applicable for all teacher and essential materials and tools should be determined and provided in order to apply the program. This programme intended to provide education regarding the ICT competencies of teachers in South Africa. The programme provides training in areas such as coding, robotics, and 3D printing. Through this programme, teachers are able to improve their knowledge and skills in these areas and apply them in the classroom. This programme ensures that teachers are fully equipped with Coding and Robotics skills.

Within the period of 4IR, we are living in a technologically advanced society, and students and teacher educators must be adequately prepared to succeed within this progressive society (Govender, 2021). Robotics Education South Africa (RESA) is an organisation that provides robotics training and support to teachers in South Africa. They offer a range of programmes and resources that help teachers to integrate robotics into their teaching. Teachers are trained through face-to-face workshops and access to educational resources, all of which are designed to support teachers in enhancing their skills in teaching robotics.

Training teachers with coding and robotics can have a noteworthy impact on education. It enhances teacher's technical skills and confidence in teaching STEM subjects. The teacher contributes to a broad variety of cognitive, metacognitive, and motivational-affective learning outcomes by selecting and executing curricular content and providing adequate learning and socio-emotional support to pupils (Mohamad et al., 2022). Educators learn to design engaging, project-based lessons that foster collaboration and creativity. Social constructivism encouraging collaborations among teachers can help to identify and address training needs. Coding and robotics skills are important for learners to succeed in an increasing digital world. Effective teacher training will ensure that teachers feel confident and equipped to teach Coding and Robotics.

Teacher collaboration

Collaboration with colleagues who have experience in this subject is promoted. According to Hali et al. (2021), “collaborative learning allows students to engage with peers and establish intellectual relations and alternate ways of comprehension” (p.22). Peer mentoring can provide valuable insights and practical tips. They learn step-by-step, from how to build a basic robot to how to code its movements. Along the way, they talk through ideas, delegate tasks, and

troubleshoot as a team. The results are more than technical know-how they gain confidence, develop patience, and form strong bonds with their peers.

Effective collaboration can lead to sharing workload, responsibilities, building trust and understanding among team members. This involves real-time collaboration, allowing developers to edit, review, and discuss code changes together. Team workload sharing provides a way to ameliorate a lack of trust in low conscientious teammates (Pradhan et al., 2024). This approach promotes teamwork, enhances code quality, and accelerates the development process. Collaborative coding tools and platforms facilitate communication and coordination among team members, enabling seamless collaboration regardless of geographical location.

Educational Resources

Use of online resources available, these comprise tutorials, lesson plans and forums where educators share their experiences and solutions. Introducing coding and robotics into educational settings or personal projects requires a collection of resources to ensure a seamless and effective learning experience. Schools need to ensure that all essential resources needed for coding and robotics are available, including hardware, such as reliable computers or laptops with sufficient processing power and memory. They also require software like platforms like Scratch, Python, or Arduino IDE (Caps 123, 2023).

Coding and robotics enhances cognitive skills, where learners can develop critical thinking, problem-solving, and analytical skills. The accessibility to resources can sometimes be a constraint, especially in educational settings, where it is important to arrange based on the goals of the coding and robotics programme. Education is already playing a key role in raising alertness and spreading information about robotic systems, and there is a growing need to create highly accessible resources to teach and learn robotics (Pozzi et al., 2021). Schools should explore grants, donations, or partnerships to acquire the necessary resources. In the absence of all required resources, schools should opt for unplugged coding, which is much cheaper than plugged.

On the other hand, without proper teacher training, learners may lose interest in STEM subjects if teachers are not equipped to teach coding and robotics effectively. Govender et al. (2025) noticed that “due to poor exposure to or experience of programming and, consequently, weak foundational knowledge of coding, many students tend to shy away from programs at tertiary

levels that include computer programming” (p.2). Learners may miss out on valuable skills and knowledge that are increasingly important in the digital workplace.

6.4 Conclusion

By addressing these challenges, educators and policymakers can work to ensure that learners receive high-quality coding and robotics education. The Department of Education ought to ensure that teachers have access to necessary resources, like robotics kits and software, can facilitate effective teaching. Providing ongoing professional development opportunities for teachers can help address gaps in their training. Integrating coding and robotics into subjects like math and language arts can make learning more holistic and relevant.

CHAPTER SEVEN: CONCLUSION AND LIMITATIONS

7.1 Introduction

Implementing coding and robotics in rural South African schools comes with its own set of challenges, but there are also opportunities for growth and development. Coding and robotics are indispensable in today's technology-driven world, offering abundant benefits for students and professionals alike. This enhances critical thinking and problem-solving abilities, allowing individuals to approach complex tasks with creative and systematic strategies.

7.2 Limitations

It would be ideal to conduct this research again in other rural schools after five years. Certain research constraints pertained. In some schools I had to wait more than two hours to meet the teachers, and schools were not consistent on their stipulated times to conduct the study. The researcher spent limited time with the participants, with the maximum of only four weeks to collect the data. It was very difficult to meet with experience teachers as they were busy with departmental meetings. For semi-structured interviews, I was in contact with five teachers, as my participants instead of 16 participants, I missed the voices of eleven teachers, where a larger cohort of participants would have been favoured.

The research focused on the small sample size as it only focused on four schools of the Alfred Nzo West district in Eastern Cape. Moreover, within the sample size, most teachers were allocated to teach coding and robotics without the qualifications. The 16 teachers who participated limited the generalisability of the study. This study's findings cannot be applied to a wider population; hence a future study could adopt a larger sample size with quantitative methods.

The majority of the participants lacked information on the study that was conducted. Coding and Robotics is still a new subject introduced in 2019, where participants were still unfamiliar with this subject. The participants were not well-trained and informed about coding and robotics. This research only targeted schools in rural areas, whereas there are other institutions that use robotics located in township and urban context, hence a comparative study could be carried out.

7.3 Conclusion

This study explores the experiences of teachers teaching coding and robotics in rural schools of Alfred Nzo West District in Eastern Cape. The government introduced coding and robotics as a way to eliminate the imbalances that rural schools face in the knowledge and practice of the latest technologies in the classroom and the development of reliable and relevant learning experiences for the citizenship of the 21st century. It was found that these schools are struggling, and some stopped teaching this subject, due several challenges. Overall, coding and robotics are powerful tools that can empower learners, transforming industries and leading to better standard of living.

Integrating coding and robotics into the South African education system paves the way for equipping students with the necessary skills to excel in the rapidly advancing 4IR. Coding and robotics are being integrated in to South African schools to equip learners with essential digital skills for the future. This subject enhances core competencies, such as problem-solving and critical thinking, while simultaneously fostering a culture of creativity and innovation. Learning coding and robotic can prepare learners for future where automation and AI are increasingly dominant.

These findings reveal that several challenges hinder the widespread adoption of coding and robotics in rural schools. Access to technology is one of the biggest issues, especially in rural and underprivileged areas. Many schools lack the infrastructure, internet access, and equipment necessary to teach these subjects effectively. Limited digital skills among educators in rural areas poses a challenge to equal access to coding and robotics education. There is also a shortage of qualified teachers trained in these areas, which makes implementation difficult.

Teachers who are not adequately trained may feel uncertain or insecure about teaching coding and robotics, which can affect their teaching performance. Inconsistent teacher training can lead to varying levels of coding and robotics education across schools, making it challenging to assess learner's progress. Poor teacher training can intensify existing inequalities in education, particularly for learners from disadvantaged backgrounds.

It was highlighted that teachers did not receive proper training and schools do not have technological infrastructure to integrate to this subject. Teachers showed willingness and eagerness to teach about coding and robotics. The researcher introduced unplugged coding to these teachers, who showed great enthusiasm for it, and who performed collaborate in all

unplugged activities. I propose that all the schools without necessities for coding and robotics undertake unplugged activities. For proper introduction of Coding and Robotics as a formal subject, the government ought to ensure that all schools are equipped with reliable access to digital tools, fostering an environment that promotes their effective use, and ensuring that the resources meet high quality standards. It is of good use to for the government to provide equal educational opportunities for all inhabitant of South Africa.

With collective efforts from policymakers, government, educators, and stakeholders, can equip learners with essential computational skills for a technology driven future. The digital divide makes it difficult to implement CT activities and forces most schools to rely on low-tech or unplugged methods. Through available programming, learning tools and combined with appropriate teaching approaches, learners can develop skills and knowledge in science, technology, engineering, and mathematics.

The researcher introduced various unplugged coding activities to teachers on workshops. In another workshop, teachers were instructed to create necklaces using beads and this demonstrated binary code. These teachers managed to construct the necklaces for the very first time, the workshops demonstrated that unplugged coding is possible in rural schools. Unplugged coding are activities that can help learners to develop computational thinking skills, problem-solving abilities, and logical reasoning, all without the need for digital devices.

Coding and robotics ought to be brought to learners in rural school irrespective of the schools' conditions, and learners should not be deprived of their right to learn new skills. Full implementation of this subject can help to ease the high rate of unemployment, as many teachers to teach it will be demanded. It should be compulsory that all schools offer coding and robotics or unplugged coding. In summation, the South African government ought to make it possible for all learners in South Africa to acquire this subject.

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APPENDICES

Appendix A: Turn- it-in report

GOQWENI ZIMBINI MASTERS COURSEWORK

ORIGINALITY REPORT

11%

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Appendix B: Editor's report

PRO EDIT PTY LTD

PO BOX 23081, CLAREMONT CAPE TOWN 7735

EDITING CERTIFICATE

Date: 2025/11/8

This serves to confirm that the document entitled:

Teaching coding and robotics in rural schools

By

Zimbini Goqweni

has been language edited on behalf of its author.

Genevieve Wood
Pro Edit Pty Ltd

Appendix C: Ethical clearance



06 November 2024

School of Education
Edgewood Campus

Dear Z Goqweni,

Protocol reference number: HSSREC/00007420/2024

Project title: A case study of teaching coding and robotics in rural schools

Degree: Masters

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 01 August 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,

Professor Dipane Hlalele (Chair)
/nng

Humanities and Social Sciences Research Ethics Committee

Postal Address: Private Bag X54001, Durban, 4000, South Africa

Telephone: +27 (0)31 260 8350/4557/3587 Email: hssrec@ukzn.ac.za Website: <http://research.ukzn.ac.za/Research-Ethics>

Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

INSPIRING GREATNESS

Appendix D: Permission from the department of education



**PROVINCE OF THE EASTERN CAPE
DEPARTMENT OF EDUCATION
ISEBE LEZEMFUNDO**

ALFRED NZO WEST DISTRICT
CNR. OF INKOSI SENYUKELE JOJO AND NTSIZWA STREET, MOUNT AYLIFF, 4735.
REPUBLIC OF SOUTH AFRICA, * Cellphone No. [REDACTED] * E-mail: Nandi.Dabula@ecdoe.gov.za

Department of education
Alfred Nzo District
5090

Dear Ms Goqweni Z

RE-PERMISSION TO CONDUCT A STUDY RESEARCH IN THE ALFRED NZO DISTRICT

The above subject refers:

Permission is hereby given to Ms Goqweni Z to conduct a research study towards her Masters, Her topic is Teaching Coding and Robotes in rural Schools.

She has targeted the following school for research:

- Zinyosini S.S.S
- Mahamane Primary
- Sakhisizwe S.P.S
- Zwelakhe S.S.S

This office wishes to be apprised of your findings and the communication prior to the publication of this research, so as to inform our planning and operations.

I also extend best wishes and success in your research and studies.

Kind regards

[REDACTED SIGNATURE]
DABULA NM (ACTING DISTRICT DIRECTOR)

GATEKEEPER'S LETTER

DEPT OF EDUCATION
ZINYOSINI S. S. S.
P. O. BOX 146, MOUN [REDACTED] 5090
D/PRINC. SIGN: [REDACTED]
DATE: 22.07.2024

GATEKEEPER'S LETTER

Dear Sir/Madam,

I am writing to ask your permission to conduct research at your School for a study entitled Teaching Coding and Robotics in rural in the Alfred Nzo West District of Eastern Cape in South Africa, which has been given ethical clearance.

This research is being conducted by **Goqweni Zimbini** from **University of KwaZulu Natal** as part of Master of Education. The study has been approved by **University of KwaZulu Natal** Research Ethics Committee and, as part of that approval process, I am required to obtain gatekeeper permission from sites where I recruit or interview participants.

The broad aim of this study is to explore Coding and Robotics teachers in the Alfred Nzo West District of Eastern Cape in South Africa. Explore what are teachers' experience in teaching coding and robotics in rural schools? How does teaching coding and robotics impact rural schools? And what are the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools? The project consists of a 15 questionnaires, workshops and observation and interviews of focus groups.

If you are willing to be involved would you please sign the form below that acknowledges that you have read the Participant Information Sheet, you understand the nature of the study being conducted and the risks and likely benefits of participation in this study, and you give permission for the research to be conducted at the site.

Yours sincerely

Goqweni Z

I [Name: 


of [Site Name: TEACHING CODING & ROBOTICS] give my permission for the study to be conducted. I reserve the right to withdraw this permission at any time.

Signature:  Date: 31-05-2024

GATEKEEPER'S LETTER

Dear Sir/Madam,

I am writing to ask your permission to conduct research at your School for a study entitled Teaching Coding and Robotics in rural in the Alfred Nzo West District of Eastern Cape in South Africa, which has been given ethical clearance.

This research is being conducted by **Goqweni Zimbini** from **University of KwaZulu Natal** as part of Master of Education. The study has been approved by **University of KwaZulu Natal** Research Ethics Committee and, as part of that approval process, I am required to obtain gatekeeper permission from sites where I recruit or interview participants.

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Yours sincerely

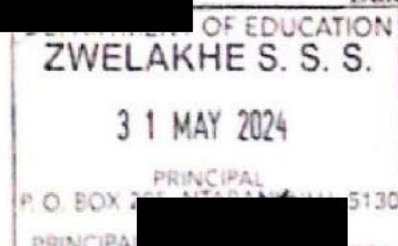
Goqweni Z.

I [Name: [REDACTED]] as [Role: [REDACTED]] Title: [REDACTED]

of [Site Name: [REDACTED]] having been fully informed of the nature of the research to be conducted in [Study Name: Teaching Coding and Robotics] give my permission for the study to be conducted. I reserve the right to withdraw this permission at any time.

Signature: [REDACTED]

Date: 31/05/2024



Ask AI

GATEKEEPER'S LETTER

Dear Sir/Madam,

I am writing to ask your permission to conduct research at your School for a study entitled Teaching Coding and Robotics in rural in the Alfred Nzo West District of Eastern Cape in South Africa, which has been given ethical clearance.

This research is being conducted by **Goqweni Zimbini** from **University of KwaZulu Natal** as part of Master of Education. The study has been approved by **University of KwaZulu Natal** Research Ethics Committee and, as part of that approval process, I am required to obtain gatekeeper permission from sites where I recruit or interview participants.

The broad aim of this study is to explore Coding and Robotics teachers in the Alfred Nzo West District of Eastern Cape in South Africa. Explore what are teachers' experience in teaching coding and robotics in rural schools? How does teaching coding and robotics impact rural schools? And what are the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools? The project consists of a 15 questionnaires, workshops and observation and interviews of focus groups.

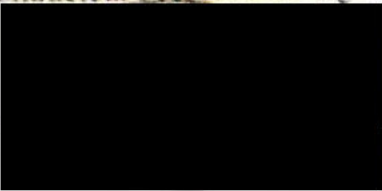
If you are willing to be involved would you please sign the form below that acknowledges that you have read the Participant Information Sheet, you understand the nature of the study being conducted and the risks and likely benefits of participation in this study, and you give permission for the research to be conducted at the site.

Yours sincerely

Goqweni Z

I [Name 

of [Site Name CODING AND ROBOTICS] give my permission for the study to be conducted. I reserve the right to withdraw this permission at any time.

Signature 

3/3

Date:

03/06/2024

Appendix F: Informed consent letter to participants

Dear Participant,

My name is Goqweni Zimbini student no [REDACTED] I am a Masters candidate studying at the University of KwaZulu-Natal, Edgewood Campus. The title of my research is A Case Study of teaching Coding and Robotics in a Rural School. The aim of the study is to:

1. To explore the experiences of teachers teaching coding and robotics in rural school.
2. To know the impact of teaching coding and robotics in all rural schools.
3. Explore the teaching of coding and robotics through a non-digital medium.

I am interested in interviewing you so as to share your experiences and observations on the subject matter.

Please note that:

- The information that you provide will be used for scholarly research only.
- Your participation is entirely voluntary. You have a choice to participate, not to participate or stop participating in the research. You will not be penalized for taking such an action.
- Your views in this interview will be presented anonymously. Neither your name nor identity will be disclosed in any form in the study.
- The interview will take about 4 weeks.
- The record as well as other items associated with the interview will be held in a password-protected file accessible only to myself and my supervisors. After a period of 5 years, in line with the rules of the university, it will be disposed by shredding and burning.
- If you agree to participate, please sign the declaration attached to this statement

I can be contacted at: Email: [REDACTED]

My supervisor is Dr R.G Govender and he can be contacted on:

Email address [REDACTED]

DECLARATION

I..... hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire. I understand the intention of the research. I hereby agree to participate.

I consent / do not consent to have this interview recorded (if applicable)

SIGNATURE OF PARTICIPANT

DATE

..... **Appendix G:**
Questionnaires A

1. How old are you?

- ☐ 20 to 30 years
☐ 31 to 40 years
☐ 41 to 50 years
☐ 51 to 60 years

2. What are your qualifications?

3. Do you teach coding and robotics in your school?

- ☐ Yes
☐ No

4. When did you start teaching coding and robotics?

5. What is robotics?

6. How many times do you teach coding and robotics in a week?

7. How would you rate yourself on teaching coding and robotics?

- ☐ Very High Confidence
☐ High Confidence
☐ Fair Confidence
☐ Below Average Confidence
☐ Low Confidence

8. Based on your response 7. Why did you rate yourself as such?

9. How do you feel about coding and robotics?

10. Do you think coding and robotics is beneficial to learners?

11. Has the department conducted any training?

12. Do you think technology infrastructure in your school is adequate for modern training?

- ☐ Yes
☐ No
☐ Not sure

13. How would you rate the infrastructure in your school?

- ☐ Very good
☐ Good
☐ Acceptable
☐ Poor
☐ Very poor

14. Have you ever heard about unplugged coding? If yes where?

15. Are you interested to learn about unplugged coding

Appendix H: Workshop 1: Robotic skills

Robotics help learners to think creatively and critically. Encourage learners to think outside the box and come with original ideas. Enables learners to increase their problem-solving abilities. Helps learners to learn 21st century skills. It develops teamwork and collaboration skills in learners (DBE, 2019)

Activity 1

1. Find something treasure in the house or outside, and hide it somewhere, not necessarily fragile. Example a stuffed animal, toy, or mom's favourite pillow seems to work perfect.



Source CAPS 123, 2023

2. Choose a spot in the house to act as the starting point. From there your pirate coders will need to write out the directions to the treasure using their compass and counting their steps.

Rubric

An example of a treasure map algorithm would be:

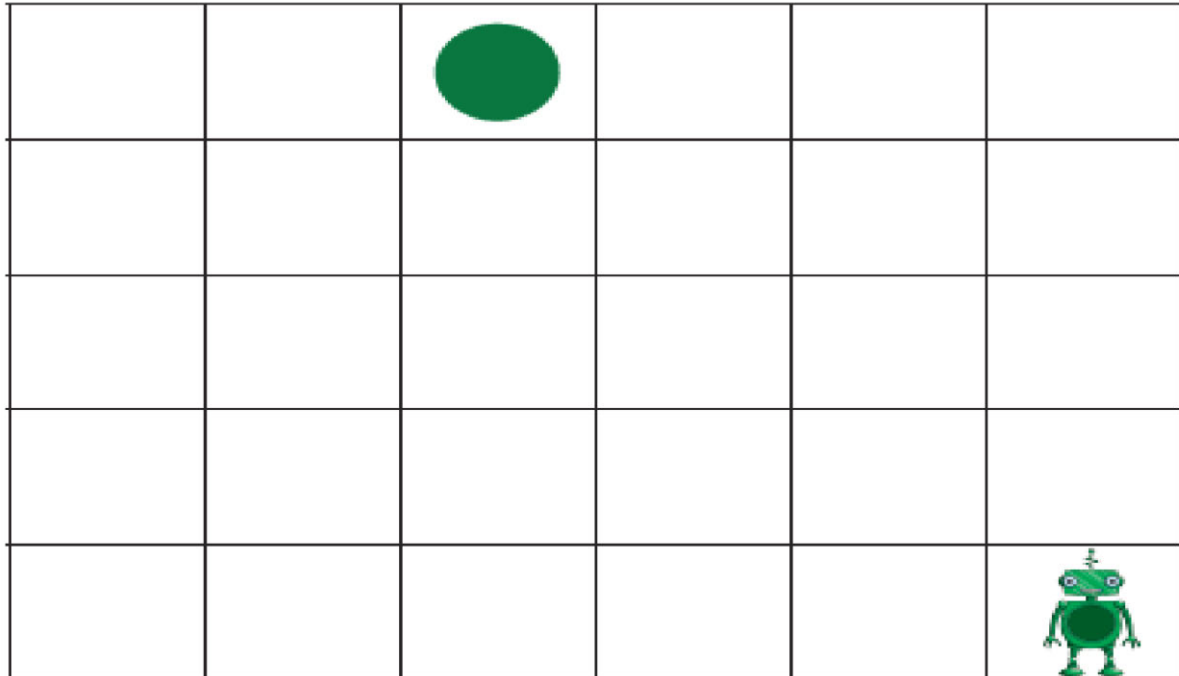
1. Head NORTH 10 steps
2. Head EAST 5 steps
3. Head North 5 steps
4. Head SOUTH 8 steps
5. Look down for the treasure!
3. The further away from the treasure the starting point is, the harder this activity becomes.

Activity 2

Robots Sort the Sequence

I can sequence commands to create an algorithm

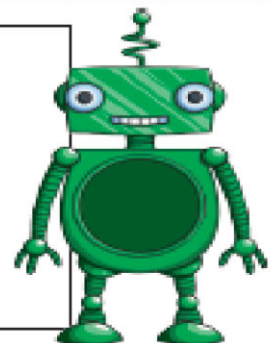
Robot Green needs to charge up on the green spot. Unfortunately his commands have all got muddled up. Can you put the commands in the correct sequence to guide him to the green spot?



Oops!

forward 2
forward 2
turn 90° left
turn 90° right
forward 3

Sorted!



Source CAPS 123, 2023 Rubric

Robot move up forward 2 and again forward 2, then turn left forward 3.

Or turn left forward 3 and upward 2 and upward 2

Appendix I: Robotic skills observation schedule

TOPIC1: ROBOTIC SKILLS

RESEACHER OBSERVATION SCHEDULE

NAME: DATE: TEACHERS OBSERVED: TIME: OBSERVER: GOQWENI Z.

Unacceptable Improved Acceptable Excellent

A. Class Structure

Today's course content	☐	☐	☐	☐
Gives an overview of the day's course content	☐		☐	☐
Summaries course content covered	☐		☐	☐
Directs teachers' preparation for the next workshop	☐		☐	

Comments

B. Methods

Provides well-designed materials	☐	☐	☐	☐
Employs non-teacher learning activities	☐		☐	☐
	☐	☐	☐	☐
Employs other tools/instructional aids	☐	☐	☐	☐
Delivers well-planned activities				

Comments

C. Researcher-teacher Interaction

Solicits teachers in	☐	☐	☐	☐
Involves teachers	☐	☐	☐	☐
Demonstrates awareness of individual teacher learning needs	☐	☐	☐	☐
Dependence among teachers	☐	☐	☐	☐

Comments

--

D. Content

Appears knowledgeable & organised

☐☐☐☐

Explains concepts clearly

☐☐☐☐

Relates concepts to teachers' experience

☐☐☐☐

Selects learning experiences appropriate to level of learning

☐☐☐☐

Comments

--

Appendix J: Robotics skills questionnaires B evaluation

Rate the following by completing the Likert scale to measure the perceived difficulty or ease of something, with 1= "very difficult" or 5= "very easy"

1. What is your view of the topic?

2.

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

3. What is your view of the activity that was completed together in this topic?

- 4.
- | | | | | |
|----------------|-----------|---------|------|-----------|
| 1 | 2 | 3 | 4 | 5 |
| Very difficult | Difficult | Neutral | Easy | Very Easy |

5. What is your view of the activity that you have completed on your own in this topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

What is your view of being able to implement these activities in your classroom?

- K:**
- | | | | | |
|----------------|-----------|---------|------|-----------|
| 1 | 2 | 3 | 4 | 5 |
| Very difficult | Difficult | Neutral | Easy | Very Easy |
- Appendix**

What is your view of implementing these activities in a rural school?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

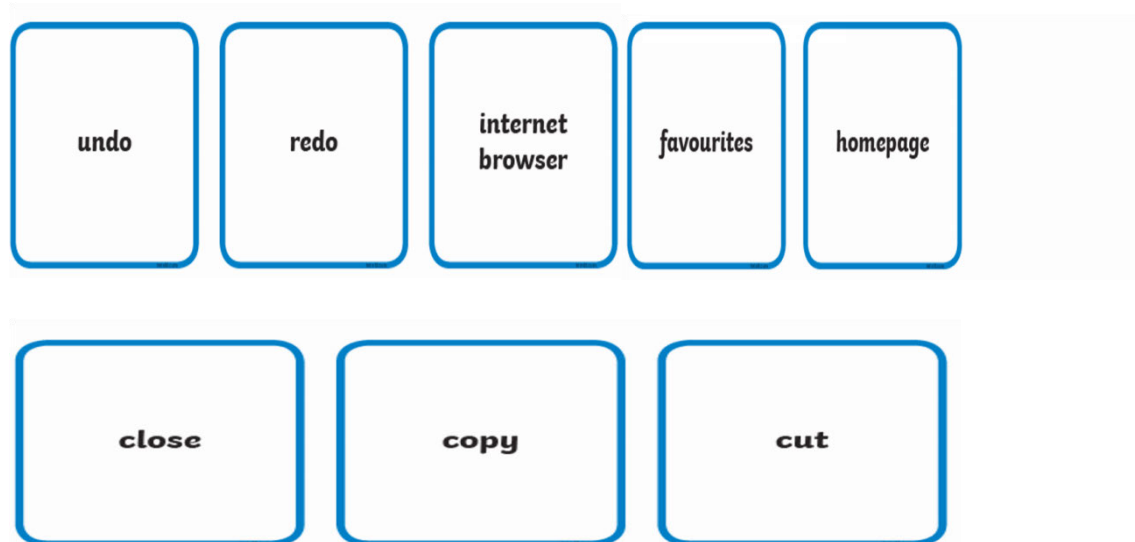
Workshop 2: internet and e-communication skills

Internet and e-communicating- covers topics such as digital identities, safety on digital platforms, an introduction to networks and the internet, and the use of web browsers to search for information. Application skills-This strand involves education in text editing and spreadsheet applications, as well as digital gadget usage. This exhibit intends to cultivate enduser abilities relevant to multiple digital platforms. Students are expected to apply programmes that expand upon their data analysis and website construction skills at the senior level (Keninda, 2023).

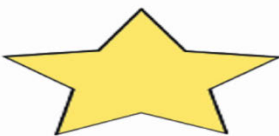
Activity 1: Match an icon with the correct descriptions



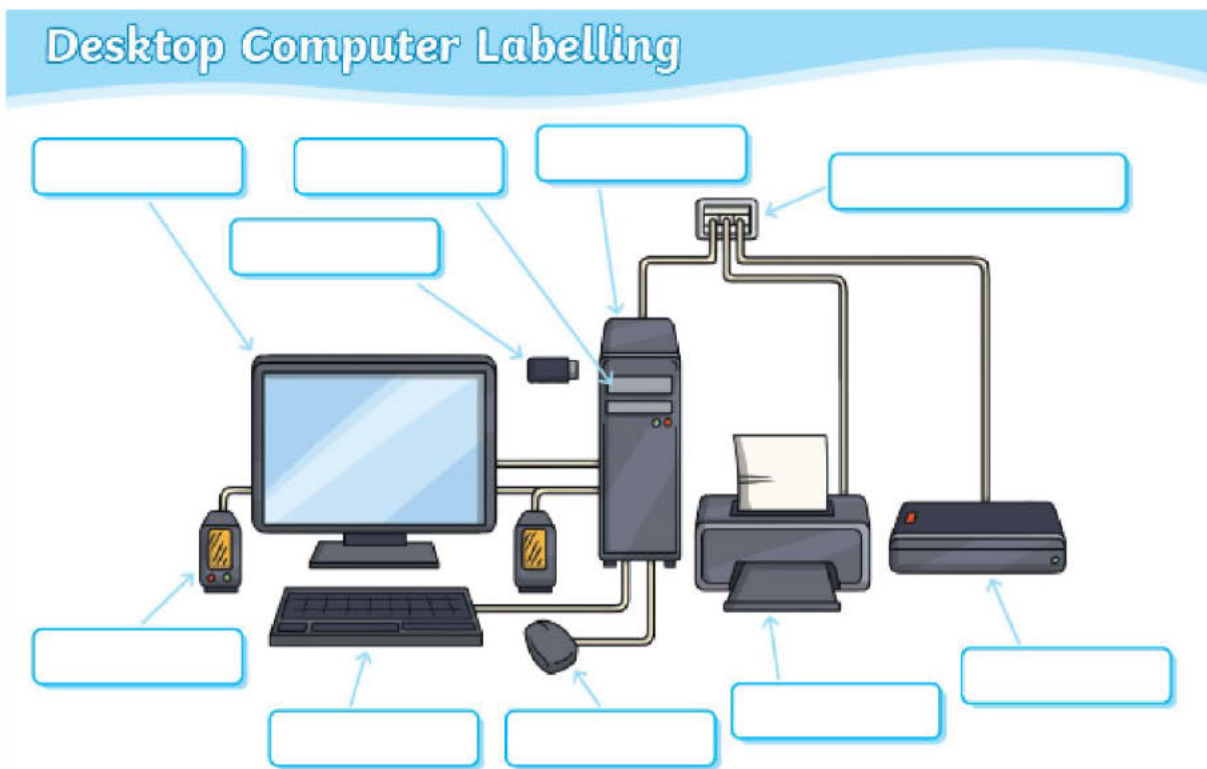
Source CAPS 123, 2023



Rubric

		
close	copy	cut
		
undo	redo	internet browser
		
favourites	homepage	

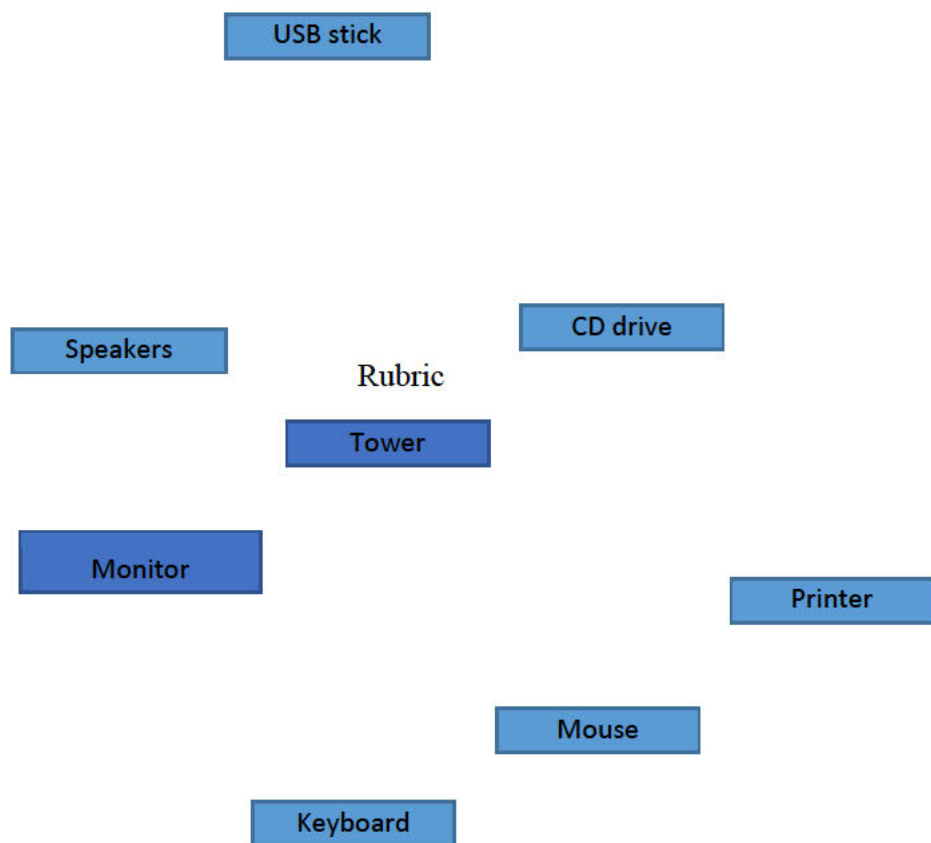
Activity 2: Label the desktop computer



Source CAPS 123, 2023

Network point

Scanner



Desktop Computer Labelling



TOPIC4: Internet and ecommunication

RESEACHER OBSERVATION SCHEDULE

NAME: **DATE:** **TEACHERS OBSERVED:** **TIME:** **OBSERVER:** GOQWENI Z.

Unacceptable Improved Acceptable Excellent

E. Class Structure

Today's course content	☐	☐		☐	☐	☐	☐	☐	☐
Gives an overview of the day's course content	☐				☐	☐		☐	☐
Summaries course content covered	☐				☐	☐			
Directs teachers' preparation for the next workshop	☐				☐	☐			

Comments

F. Methods

Provides well-designed materials	☐		☐		☐		☐		☐
Employs non-teacher learning activities	☐				☐		☐		
	☐		☐		☐		☐		
Employs other tools/instructional aids	☐		☐		☐		☐		
Delivers well-planned activities									

Comments

G.

H. Researcher-teacher Interaction

Solicits teachers in

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Involves teachers

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Demonstrates awareness of individual teacher learning needs

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Dependence among teachers

Comments

--

I. Content

Appears knowledgeable & organised

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Explains concepts clearly

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Relates concepts to teachers' experience

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Selects learning experiences appropriate to level of learning

☐	☐	☐	☐
--------------------------	--------------------------	--------------------------	--------------------------

Comments

--

Appendix M: Internet and e-communication questionnaires B evaluation

Rate the following by completing the Likert scale to measure the perceived difficulty or ease of something, with 1= "very difficult" or 5= "very easy"

1. What is your view of the topic?

2.

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

3. What is your view of the activity that was completed together in this topic?

4.

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

5. What is your view of the activity that you have completed on your own in this topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

What is your view of being able to implement these activities in your classroom?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

What is your view of implementing these activities in a rural school?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

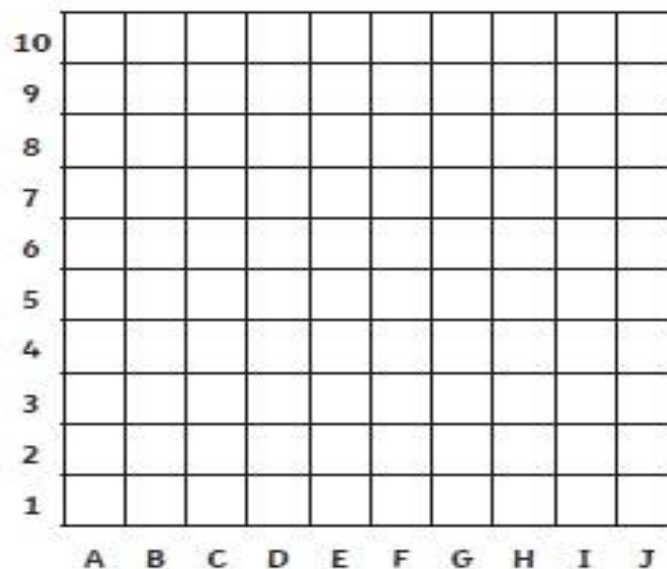
Appendix :
N Workshop 3: Algorithm

Enable learners to break down complex tasks into manageable steps. Allows learners to approach challenges systematically and logically. Improves problem-solving skills. Provide a structured approach to problem solving. Help to predict trend, optimise and solutions (DBE, 2019).

ACTIVITY 1

Plot the grid references on the grid.

Remember to plot grid references, you need to go along the street before you climb up the sky.



Dark Grey					Light Grey	Black	Pink
A,7	C,8	E,6	G,5	I,7	B,8	D,7	C,4
A,8	C,9	E,7	G,6	I,10	B,9	E,3	H,4
A,9	C,10	E,8	G,8	J,7	I,8	E,4	
A,10	D,2	F,2	H,3	J,8	I,9	E,5	
B,7	D,3	F,6	H,5	J,9		F,3	
B,10	D,4	F,7	H,6	J,10		F,4	
C,3	D,5	F,8	H,7			F,5	
C,5	D,6	G,2	H,8			G,7	
C,6	D,8	G,3	H,9				
C,7	E,2	G,4	H,10				

Activity 2

Use the binary key below, grey presents 0 and white 1. Write your name using binary by colouring in the boxes on the provided sheet. Colour in the zeros red and the ones blue. Colour in a space after every letter yellow

Letter	Binary	Letter	Binary
A		N	
B		O	
C		P	
D		Q	
E		R	
F		S	
G		T	
H		U	
I		V	
J		W	
K		X	
L		Y	
M		Z	

Source CAPS 123, 2023

Appendix :

O Algorithms observation schedule

TOPIC3: ALGORITHM

RESEACHER OBSERVATION SCHEDULE

NAME: DATE: TEACHERS OBSERVED: TIME: OBSERVER: GOQWENI Z.

Unacceptable Improved Acceptable Excellent

J. Class Structure

Today's course content	☐	☐	☐	☐	☐	☐	☐	☐	☐
Gives an overview of the day's course content	☐				☐	☐		☐	
Summaries course content covered	☐				☐	☐			
Directs teachers' preparation for the next workshop	☐				☐	☐			

Comments

K. Methods

Provides well-designed materials

Employs non-teacher learning activities

☐	☐	☐
--------------------------	--------------------------	--------------------------

Employs other tools/instructional aids	☐	☐	☐	☐
Delivers well-planned activities	☐	☐	☐	☐
<i>Comments</i>	☐		☐	☐
	☐			

L. Researcher-teacher Interaction				
Solicits teachers in	☐	☐	☐	☐
Involves teachers	☐	☐	☐	☐
Demonstrates awareness of individual teacher learning needs	☐	☐	☐	☐
Independence among teachers	☐	☐	☐	☐

Comments

M. Content				
Appears knowledgeable & organised	☐	☐	☐	☐
Explains concepts clearly	☐	☐	☐	☐
Relates concepts to teachers' experience	☐	☐	☐	☐
Selects learning experiences appropriate to level of learning	☐	☐	☐	☐

Comments

Appendix :

P Algorithm questionnaire B evaluation

Rate the following by completing the Likert scale to measure the perceived difficulty or ease of something, with 1= "very difficult" or 5= "very easy"

1. What is your view of the topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

2. What is your view of the activity that was completed together in this topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

3. What is your view of the activity that you have completed on your own in this topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

4. What is your view of being able to implement these activities in your classroom?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

5. What is your view of implementing these activities in a rural school?

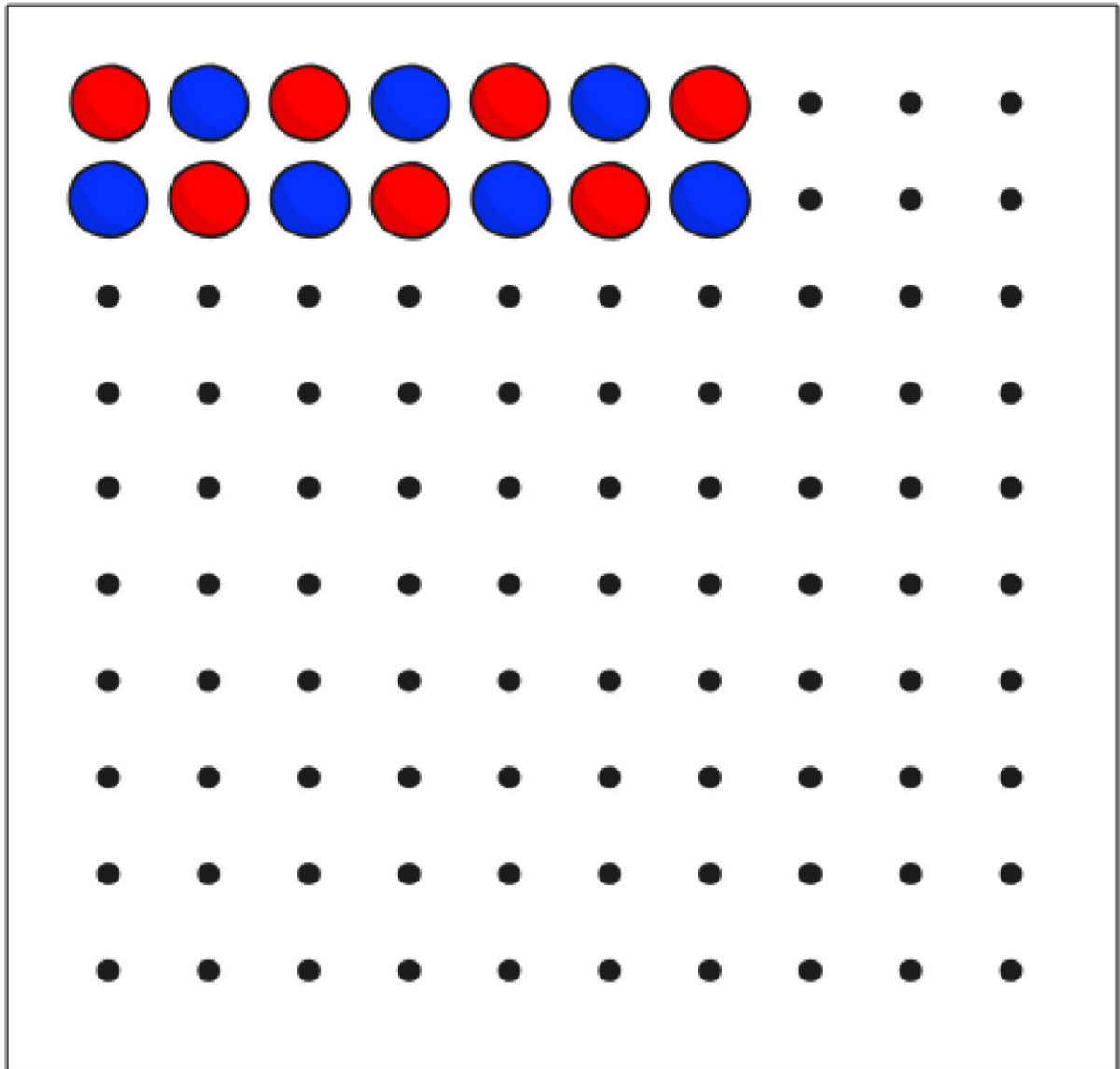
1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

Appendix Q: Workshop 4: Pattern recognition

Activity 1

Complete the pattern

Appendix :



Source CAPS 123, 2023

Activity 2: Beaded Bracelets

Individual | Materials: Multi-coloured beads, string



Source: *Mattingly,*

2020

1. Cut a piece of string so it is just longer than wrist-size. Tie a knot at the end of a string.
2. Decide on a pattern of 3 beads that you want to repeat multiple times in your bracelet. For example, Pink-Blue-Pink. We can call this set of beads a “function”.
3. Start stringing beads onto the yarn. After 5 beads, add your first “function”. In this example, this means the pattern of Pink-Blue-Pink.
4. Add 5 more beads. Then, add your function again. Repeat this process until the string is full with beads.
5. Tie a knot on the other end and display your finished bracelet!
6. Observe carefully

7. How many times were you able to repeat the function beads?

Appendix R: Patterns and recognition observation schedule

TOPIC4: PATTERNS AND RECOGNITION

RESEACHER OBSERVATION SCHEDULE

NAME: DATE: TEACHERS OBSERVED: TIME: OBSERVER: GOQWENI Z.

Unacceptable Improved Acceptable Excellent

N. Class Structure

Today's course content	☐	☐		☐	☐	☐	☐	☐	☐
Gives an overview of the day's course content	☐				☐	☐		☐	
Summaries course content covered	☐				☐				
Directs teachers' preparation for the next workshop	☐				☐				

Comments

O. Methods

Provides well-designed materials	☐
Employs non-teacher learning activities	

	☐	☐	☐
Employs other tools/instructional aids	☐	☐	☐
Delivers well-planned activities	☐	☐	☐
Comments	☐	☐	☐
	☐		

P. Researcher-teacher Interaction

Solicits teachers in	☐	☐	☐	☐
Involves teachers	☐	☐	☐	☐
Demonstrates awareness of individual teacher learning needs	☐	☐	☐	☐
Dependence among teachers	☐	☐	☐	☐

Comments

Q. Content

Appears knowledgeable & organised	☐	☐	☐	☐
Explains concepts clearly	☐	☐	☐	☐
Relates concepts to teachers' experience	☐	☐	☐	☐
Selects learning experiences appropriate to level of learning	☐	☐	☐	☐

Comments

Appendix S: Pattern recognition questionnaire B evaluation

Rate the following by completing the Likert scale to measure the perceived difficulty or ease of something, with 1= "very difficult" or 5= "very easy"

1. What is your view of the topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

2. What is your view of the activity that was completed together in this topic?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

What is your
view of being
able to
implement
these activities
in your
classroom?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

What is your view of
implementing these activities in
a rural school?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

activity that you have completed on your own in this topic?

3.
What
is your
view
of the

4.

5.

Appendix T: Semi-structured interviews

During the interviews, teachers will be encouraged to share the strategies and challenges involved in teaching coding and robotics through a non-digital medium in rural schools.

1. Have you ever seen a robot in your life? If yes, where did you see it? What were the characteristics of the robot?
2. Would you like to design a robot? Why?
3. If you were to design a robot, what would be the characteristics of the robot you designed?
4. Would you like to take coding training?
5. What do you need to be able to code?
6. When introducing coding robots to young learners what are the challenges you encountered into the classroom?
7. Are you able to integrate coding and robotics to existing curriculum?
8. What do you do to deal with technical issues like hardware malfunctions to software glitches?
9. What are the challenges that schools experience when integrating technology?
10. Are coding robots beneficial for young children's learning?
11. What are the challenges of robotics in education?
12. What are the challenges and barriers of integrating technology?