Teachers' and learners' acceptance of the use of robotics in the Intermediate Phase

By Doctor Mapheto

Submitted in fulfilment of the requirements

for the degree in Magister Educationis in the Faculty

of Education, University of Pretoria.

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Declaration

I hereby certify that the dissertation I am submitting to the University of Pretoria for the degree of Magister Educationis is unique to me and has never been submitted by me for a degree at this or any other higher education institution.

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Fakulteit Opvoedkunde

Dedication

I dedicate this study to the following people:

Firstly, I dedicate this study to my fiancée Gugu Dlamini, my daughter Itumeleng Dlamini and my son Koketso Dlamini who have been supportive, encouraging and patient with me through my studies. They will always be in my heart at all times. Thank you for your support and perseverance.

Lastly, I dedicate this study to my late dad Isaac Moloko Mapheto who has been my mentor and always been there for me through my hardships. Your passion and dedication for education really encouraged me to further my studies thus far. Thank you so much and may your soul continue to rest in peace.

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Abstract

The purpose of this study was to explore teachers' and learners' acceptance of the use of robotics in the Intermediate Phase. The study explored teachers' and learners' acceptance of the use of robotics based on their attitudes and experiences in two primary schools, which integrate robotics as a learning tool. Robotics is the current digital technology in the educational sector and offers new possibilities for modelling teaching and learning. Hence, user acceptance is one of the key aspects, which should be taken into consideration when new technology is introduced. The study used the Technological Acceptance Model (TAM) as the theoretical framework. Data was composed by integrating a qualitative approach through field notes, data analysis and semi-structured interviews. The researcher purposively sampled nine learners and nine teachers from the two identified schools in Pretoria, Gauteng. Content analysis was utilised to summarize the data collected and to draw up conclusions based on the findings. The data was analysed using data analysis steps by arranging, reassembling and managing the data in a systematic way. The study discovered that the integration of robotics in education is demanding, costly, time consuming and requires adequate resources. Hence, it necessitates additional time to design educational programs, requires more time for workshops and solving technical glitches, and puts more pressure on teachers. Teachers need support with the resolving of hardware and software issues as well as technical maintenance. Learners perceive robotics as a positive and exciting technological learning approach, which promotes teamwork and hands-on learning.

Keywords: Robotics, Science, Technology Engineering and Mathematics, 21st century skills, Intermediate Phase teachers, user acceptance, ease of use and usefulness.

Language editors' disclaimer

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I do hereby confirm that I have proof-read the dissertation entitled –

Teachers' and learners' acceptance of the use of

robotics in the Intermediate Phase

By Doctor Mapheto.

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List of abbreviations

STEM	Science Technology Engineering and Mathematics
WRO	World Robotics Olympiad
DBE	Department of Basic Education
CAPS	Curriculum Assessment Policy Statement
4IR	Fourth Industrial Revolution
EV3	Evolution 3 (Lego Mindstorms)
DST	Department of Science and Technology
STI	Science Technology and Innovation
ATP	Annual Teaching Plan
PAT	Practical Assessment Task
SGB	School Governing Body
SMT	School Management Team
ICT	Information and Communication Technology

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Chapter 1: Introduction and background

1.1 Introduction

The integration of robotics in education has been a topic of growing interest and discussion in recent years (Ali et al., 2023). With advancements in technology, robotics has become more accessible and affordable for educational institutions, particularly in the Intermediate Phase. This phase, which typically encompasses children between the ages of 10 and 14, is a critical stage in their educational journey, as they transition from the foundational knowledge of the Primary Phase to more specialised subjects in the later stages of their schooling.

Robotics can have a variety of benefits for both teachers and learners, such as providing a more interactive and engaging learning environment (Di Battista et al., 2022). It can also give learners an opportunity to explore a wider range of topics, allowing them to gain a better understanding of the subject. Moreover, robotics can help teachers save time on administrative tasks, allowing them to focus more on teaching. Robotics can also be used to help learners to become more creative, as they can learn to build and program robots to complete tasks. Additionally, Ali et al. (2023), posit that it can help learners develop problem-solving skills and critical thinking skills. While the potential benefits of incorporating robotics into the curriculum are widely acknowledged, questions remain regarding the extent to which teachers and learners are embracing this approach.

One aspect to consider is teachers' attitudes towards integrating robotics into their classroom practices. Some teachers may view the incorporation of robotics as a valuable opportunity to engage students in hands-on, interactive learning experiences. These teachers believe that robotics can foster creativity, problem-solving, and critical thinking skills among students. They see robotics as an innovative tool that can enhance the learning process and make it more dynamic and engaging. However, it is important to note that other teachers may approach the integration of robotics with apprehension. This apprehension may stem from a lack of training or unfamiliarity with the technology. Some teachers may feel overwhelmed by the thought of incorporating robotics into their teaching practices and may perceive it as a significant departure from traditional teaching methods (Di Battista et al., 2022). Additionally, there may be concerns regarding the ability to effectively assess student learning outcomes when robotics are used in the classroom.

Given the potential benefits and challenges associated with integrating robotics into the classroom, it becomes crucial to provide adequate support and training to teachers. Teachers should be given opportunities to develop their skills and knowledge in using robotics for educational purposes (Ali et al., 2023). This could involve specialised training programs, professional development workshops, or even mentorship opportunities. By equipping teachers with the necessary skills and knowledge, they can overcome their apprehensions and embrace the potential of robotics in the classroom. Ultimately, the successful integration of robotics into classroom practices relies on the attitudes and readiness of teachers (Di Battista et al., 2022). It is essential to create a supportive environment where teachers feel empowered and confident in using robotics as a tool for enhanced learning. With the right support and training, teachers can effectively incorporate robotics into their teaching practices, ensuring that learners are engaged and equipped with essential skills for the future.

The second aspect is the perspective of learners in the Intermediate Phase as it is instrumental in determining the acceptance and effectiveness of robotics as a learning tool. It is important to recognise that students possess diverse attitudes towards Science, Technology, Engineering and Mathematics (STEM) subjects, which can significantly influence their acceptance of robotics (Di Battista et.al, 2022). While some learners may eagerly embrace the idea of robotics as a fun and engaging way to learn, others may feel intimidated or disinterested due to their limited exposure to the field. Moreover, students' prior exposure to robotics plays a significant role in shaping their acceptance of this teaching methodology. Those who have had previous experiences with robotics, such as participating in robotics competitions or attending robotics workshops, are more likely to view it positively and perceive it as an effective tool for acquiring knowledge and developing problem-solving skills (Ali et al., 2023). Conversely, learners with little to no exposure to robotics may feel uncertain or apprehensive about engaging with this unfamiliar technology.

Furthermore, learners' perceptions of the relevance of robotics to their future can influence their acceptance of using it as a learning tool. Learners who see a clear connection between robotics and their desired career paths or who recognise the growing importance of STEM disciplines in various industries are more likely to readily embrace the use of robotics in their studies. On the other hand, learners who fail to perceive the practical application of robotics in their future endeavours may question its value and resist its adoption.

Understanding the perspectives of teachers and learners is vital in determining the acceptance of robotics as a learning tool in the Intermediate Phase. Attitudes towards STEM subjects, previous exposure to robotics, and perceptions of its relevance to their future all play a crucial role in influencing teachers and learners' acceptance and engagement with robotics. By considering and addressing these factors, educators can enhance the effectiveness of using robotics to facilitate learning and foster enthusiasm among learners.

The world is moving very quickly, and technological developments are continuously increasing in all fields. Technology is unavoidable and is a vibrant portion of our lives, at the workplace or learning institutions. Therefore, it is essential for organisations to adapt and adjust towards a new technological integrated method of administering learning in their educational systems or profession (Vidal-Hall & Flewitt, 2020). Robotics has been introduced in production and educational sectors for creativity and improvement from the old methods of delivering services (Hongshuai, 2021). In the production sectors, robotics replaces the old machinery and human labour by introducing programming, which saves a lot of time in delivering the services (Dorouka et al., 2020). Whereas the integration of robotics in the educational field encourages innovative techniques for grooming learners and for developing their problem-solving skills, creativeness, social and cognitive development and social interaction skills (Dorouka et al., 2020).

Robotics incorporates Science, Technology, Engineering and Mathematics (STEM) spectrum and is a tactic to instil and strengthen STEM subjects (Dorouka et al., 2020). According to Mauch (2015) robotics in education is a purely technological approach of instilling knowledge with 21st century skills, which involves problem solving, innovation and creativity. Robotics has drawn a centre of attraction for many scholars, educators and learning institutions as an appropriate and crucial educational tool to improve different abilities from foundation phase to high school level (Mauch, 2015).

1.2 Background

This study sought to examine the integration of robotics into the curriculum of two primary schools in Pretoria East. These schools have recognised the importance of incorporating robotics as a means of equipping students with 21st century skills. To facilitate the learning process in robotics, the schools have provided the necessary resources such as tablets, laptops, EV3 bricks, data projectors, white boards, Lego Mindstorms, and Wi-Fi connection for internet access. Additionally, teachers are undergoing training and workshops to effectively deliver robotics lessons.

One notable aspect of the curriculum is the participation of learners in the annual World Robot Olympiad (WRO). This event allows learners to work in teams and compete with other schools, providing them with an opportunity to apply the skills they have acquired. The WRO offers provincial, national, and international competitions, adding an element of excitement and motivation for students to succeed.

The inclusion of robotics in education has gained attention from educators and educational institutions due to its ability to foster teamwork, promote 21st century skills, enhance learning through technology, and cultivate an enjoyable learning experience. According to Samuels (2016), competition plays a significant role in engaging students and encouraging their participation in various educational activities. In the context of robotics, learners are required to invest effort in completing missions to compete with other schools.

Furthermore, the integration of robotics in education creates numerous opportunities for both learners and teachers. It aids in the development of a deep understanding of scientific and mathematical concepts, expanding content knowledge. By incorporating robotics into the curriculum, these schools strive to provide learners with a comprehensive and relevant educational experience.

1.3 Rationale

This study aimed to explore the acceptance and experiences of learners and teachers regarding the use of robotics in the Intermediate Phase curriculum. Robotics has the potential to enhance students' communicational skills, creativity, and innovative thinking. It provides a hands-on experience that fosters constructive learning and equips learners with the necessary digital skills for the future. The findings intended to not only benefit private schools but also the Department of Education, as they are actively seeking ways to introduce robotics in public schools. Furthermore, this study provided valuable insights for teachers on accepting Lego Mindstorms Ev3 as a reliable and effective learning tool. It guided educational institutions in embracing new technological developments, leading to more dynamic and engaging learning experiences for learners. The findings can help inform educational policymakers, curriculum developers, and teachers on the effective implementation of robotics in classroom settings. By embracing this emerging technology, schools can empower students with 21st century skills and enhance their understanding of STEM fields, thereby preparing them for future challenges and opportunities in the digital world.

As a teacher of Mathematics and Science and robotics coordinator in the Intermediate Phase, I strongly believe that robotics has a huge impact in developing learners' communicational skills and gives them an opportunity to show their creativity and innovative skills with the use of programming and building the robot using their own designs. Robotics gives learners exposure and experience as a hands-on activity, which creates constructive learning and provides learners with skills of living in the digital world. However, in the primary school where I teach, robotics is only offered as a form of an extra-mural activity where only a few learners are selected based on their academic achievement to take part in the robotics team, and they are also given the opportunity to participate in the WRO.

This study will contribute positively to primary schools in the Intermediate Phase that are planning to integrate robotics in their curriculum, because learners' and teachers' acceptance and experiences towards the utilisation of robotics in the Intermediate Phase were explored. This study is based on private schools, which could benefit the

Department of Education since they are still looking to integrate robotics in public schools from Grade R-9. Moreover, this study will be valuable to support educators in accepting robotics as a learning tool; may give guidance on how educators perceive robotics as a learning device in education, and advance learning institutions to embrace new technological developments.

1.4 Problem statement

The integration of digital technologies in the educational sector has greatly impacted teaching and learning methodologies (Ali et al., 2023). While interactive whiteboards and tablet devices have become common tools in classrooms, the emergence of robotics as a digital technology presents new possibilities for education. User acceptance plays a crucial role in determining the success of implementing robotics in the educational setting. Therefore, it is important to consider the attitudes and experiences of teachers and learners when introducing robotics into the curriculum.

Despite the potential benefits of using robotics as an educational tool in South Africa, there is a lack of comprehensive research on the perceptions and acceptance of teachers towards this technology (Di Battista et al., 2022). Various studies focus primarily on the skills that learners acquire using robotics in the classroom, positioning robotics as a learning aid under the control of the teacher. The limited information available on teachers' acceptance of robotics hinders the understanding of how these technologies can effectively enhance teaching practices.

According to Jaipal-Jamani and Angeli (2017), a person's technological acceptance is a critical determinant of the success or failure of the implementation of any new technology. Therefore, it is imperative to explore the perceptions and experiences of teachers and learners towards using robotics in education. Considering these factors, a positive environment for the integration and implementation of robotics can be created.

Digital technologies have a crucial influence on the educational sector and significantly model educational principles in different phases. Currently, the integration of interactive whiteboards and tablet devices in classrooms are no longer amazing technological inventions in the current education system. Robotics is the current digital technology in the educational sector and offers new possibilities for modelling teaching and learning.

User acceptance is one of the key aspects, which should be taken into consideration when new technology is introduced, because this can influence the success of the implementation of robotics.

Few scholars have researched the acceptance of robotics in the educational setting. However, most of these studies are based on skills that learners acquire when learning with robotics in the classroom whereby the acceptance of teachers represents robotics as a learning aid to assist the teacher to administer effective teaching. Very little research is gathered on teachers' acceptance and attitudes towards the utilisation of robotics as an educational tool, even though robotics in educational sectors was implemented for teaching and learning.

1.5 Purpose statement

The purpose of this study was to determine the factors that influence teachers' and learners' acceptance of the utilisation of robotics in the Intermediate Phase. The primary source of information of this research is based on the experiences of teachers and learners about how they perceive robotics in their teaching and learning.

1.6 Research objectives

1.6.1 To identify factors that affect the acceptance of the use of robotics in the Intermediate Phase.

1.6.2 To explore the attitudes of teachers and learners in accepting the use of robotics in the Intermediate Phase.

1.6.3 To explore how easy to use and useful Intermediate Phase teachers and learners find robotics.

1.6.4 To identify the internal and external factors that influence the use of robotics in the Intermediate Phase.

1.7 Research questions

1.7.1 Primary research question:

What influences teachers' and learners' acceptance towards the use of robotics?

1.7.2 Secondary research questions

1.7.2.1 What are internal and external factors that influence the use of robotics in the Intermediate Phase?

1.7.2.2 What are the attitudes of teachers and learners towards the use of robotics?

1.7.2.3 How easy do Intermediate Phase teachers and learners find it to use robotics?

1.7.2.4 How useful do Intermediate Phase teachers and leaners find robotics in their teaching and learning?

1.8 Concept clarification

Educational robotics

It is a curriculum planned to enhance STEM related subjects in education by introducing programming and coding to teachers and learners (Dorouka et al., 2020). Educational robots gives learners opportunity to develop concrete foundation of programming, engineering and technology while they are learning other skills such as problem solving, communication and listening skills.

21st century skills

Various skills that allow learners to be updated with the changes and transformations in response to global advancements and prepares them to be able to participate in the digital world, which involves creativity, communication and critical thinking (Tohani & Aulia, 2022).

Attitudes

Refers to how an individual feels or thinks about something (Yada et al., 2022). In this study, attitudes refer to how teachers and learners feel and think about the integration of robotics in the Intermediate Phase.

Experience

The process of becoming familiar with or gaining knowledge about certain things through direct observations, hands-on activities, and practical applications (Ruggiero & Mong, 2015). In the context of this study, teachers and learners' experience refer to their knowledge of training, lessons, and teacher developmental workshops with robotics. Teachers' experience in robotics training encompasses the knowledge and skills acquired through formal training programs and professional development workshops. These include learning about the fundamental principles of robotics, understanding the functioning of robotic systems, and gaining proficiency in programming and coding. Teachers' experiences also involve the application of this knowledge in the classroom setting, where they engage students in hands-on activities and guide them in exploring the world of robotics. Learners' experience is primarily focused on their engagement with robotics within the educational context. This includes their participation in lessons and activities related to robotics, where they interact with robotic systems, develop problem-solving skills, and enhance their understanding of scientific concepts. Learners' experience may also involve collaborative work, as they engage in group tasks and projects that require them to apply their knowledge of robotics.

Acceptance

Refers to the ability to welcome or adopt something with a positive or negative attitude and it is based on previous experience (Lai, 2017). In this study, acceptance refers to the ability of teachers and learners to adopt and integrate robotics in the Intermediate Phase.

Technology integration

Is the utilisation and incorporation of technological resources to advance teaching and learning (Adegbenro et al., 2017). In this study, the integration of technology refers to teachers' and learners' utilisation and incorporation of robotics for teaching and learning.

Lego Mindstorm EV3

The Lego Mindstorm is a practical, cross-curricular STEM tool, which involves learners by introducing resources to plan, create and program their inventions while assisting them to cultivate important abilities such as creativeness, communication and critical thinking (Chambers & Carbonaro, 2018).

Self-efficacy

Is based on a set of beliefs, which control how individuals feel, contemplate, boost their self-esteem and behave, which have an impact on their attitude towards something (Jaipal-Jamani & Angeli, 2017). In this study, self-efficacy refers to teachers' and learners' beliefs towards the use of robotics.

Fourth Industrial Revolution (4IR)

Refers to quick technological developments in science, technology, engineering and processes in the 21st century due to connectivity and advanced computerisation (Gleason, 2018). The 4IR in this study refers to rapid technological developments which impact on education and necessitates a paradigm shift.

Computational thinking

It is a methodological approach to solve problems by integrating the four pillars which are algorithm design, decomposition, pattern recognition and abstraction (Acevedo-Borrega et al., 2022). The four pillars in computational thinking includes articulation of problems and their solutions in a manner that a computer could also accomplish. The teaching and learning of the robotics curriculum encompasses the four pillars whereby teachers give learners problems or scenarios without the obvious solutions. Therefore, learners have to work collectively with their peers to solve the problem by applying the four pillars.

Ease of use

Refers to how users can simply use, navigate and incorporate the device without an effort or challenges (Nguyen et al., 2020). In this study the ease of use refers to how teachers and learners find it to use robotics as a teaching and learning tool.

Usefulness

Refers to an extent in which the object or a machine is useful based on its application, features, functionality and production (Ambalov, 2021). In this study usefulness refers to how teachers and learners perceive the usefulness of robotics for teaching and learning and how robotics as a learning educational tool enhance teaching and learning.

1.9 Summary

This chapter presented the framework of the study. The objectives were discussed, and the concepts were clarified as per their relevance to this study. Teachers and learners are the main primary source of information for this study. Their experiences, attitudes and views about the integration of robotics in the Intermediate Phase will be explored. In the next chapter, the literature that supports the study and theoretical framework that underpins the study will be discussed.

Chapter 2: Literature review and theoretical framework

2.1 Introduction

This chapter reviews pertinent literature on teachers' and learners' acceptance towards the use of robotics in the Intermediate Phase. The theoretical framework will also be discussed. Robotics in education offers numerous benefits beyond technology integration. It promotes critical thinking, problem-solving skills, and creativity among learners as they engage in hands-on activities and collaborate with peers to program and control robots. Additionally, robotics education fosters an interest in STEM fields, preparing learners for future careers in technology-driven industries.

A constructivist educational setting connects learners in genuine, collaborative tasks and is focused on their comfort. In this kind of setting, technology is integrated as an instrument to sustain learners' attention and focus on the curriculum (Hubbard, 2018). The integration of technology has distorted our communities and completely transformed the way people create meanings, work and life. As part of this, learning institutions are supposed to prepare learners to participate in a digital world by considering technology integration in their curriculum (Ketelhut & Mills, 2020). As a result, robotics has been introduced in education to enhance the utilisation of technology and to prepare learners to participate in a digital world. Robots are defined as programmable machines or tools that can substitute humans in executing a variety of activities by integrating input commands (Alam, 2022).

2.2 Literature review

A literature review is a comprehensive analysis and synthesis of existing research and scholarly articles related to a specific topic or research question (Snyder, 2019). It provides an overview of the current knowledge and gaps in the field, allowing researchers to identify areas for further investigation. Conducting a literature review is essential for building a strong theoretical foundation and understanding the context of the research problem.

The purpose of a literature review is to critically evaluate and analyse the existing literature to identify key themes, trends, and gaps in knowledge. This helps researchers establish the relevance and significance of their own research and avoid duplicating previous studies (Pare, 2017). Additionally, a literature review helps researchers identify potential methodologies and theoretical frameworks that can be applied to their own research. When reviewing the literature for this study, it was important to examine trends, causes and effects, and gaps in the existing literature. The subcategories of literature were identified based on their relevance to this study, to explore teachers' and learners' acceptance of the use of robotics.

This study followed the themes in trying to understand the phenomena holistically from the existing literature. The researcher explored the factors regarding teachers’ and learners’ acceptance of robotics in the Intermediate Phase specifically focusing on experiences and attitudes with robotics in education and the factors that influence the utilisation of robotics in the Intermediate Phase. In reviewing the literature of this study, it is vital to look at some trends, cause and effects and gaps in the existing literature. To explore teachers’ and learners’ acceptance towards the use of robotics the subcategories of literature have been designated based on their significance to this study as follows:

2.2.1 The history of robotics
2.2.2 The state of robotics curriculum in the South African education system
2.2.3 Coding and robotics curriculum Grade R-9 in South Africa
2.2.4 Integration of robotics in public and private schools in South Africa
2.2.5 Robotics as an educational learning tool in the world
2.2.6 Teachers’ acceptance towards the use of robotics
2.2.7 Teachers’ and learners’ experiences with the use of robotics
2.2.8 The importance of robotics in education
2.2.9 Factors that influence the use of robotics in the Intermediate Phase

This study followed the subcategories listed above in trying to understand the phenomena holistically from the existing literature. The researcher explored the factors regarding teachers’ and learners’ acceptance of robotics in the Intermediate Phase specifically focusing on experiences and attitudes with robotics in education and the factors that influence the utilisation of robotics in the Intermediate Phase.

2.2.1 The history of robotics

The world is confronted by a more rapid technological evolution than ever, and this transformation continues to increase daily. In this rapid technological transforming world, flexibility and ability to learn innovative competencies and skills are vital (Hubbard, 2018). The advancement of technological resources and digitalisation influences all people from different ages. Therefore, the utilisation of smartphones, laptops, tablets and other technological resources that deliver both social and entertainment purposes are an essential part of everyday life. A study by Vidal-Hall and Flewitt (2020) assert that people should adapt to the transforming world of technology, acquire information and advance their technological skills to be able to add value in the digital world.

Robotics is the outcome of development, inquisitiveness, capabilities and creativity of human thought on how to make tools and machineries be able to resolve challenges and perform precise activities freely (Hongshuai, 2021). The progression of transformation through technical and material conquests has led to the construction of tools that are equipped with autonomy and skills. The evolution of robotics is entangled with the histories of technological developments, engineering and science. Technology used in computer science, manufacturing of cars, even advanced electronical gadgets, engineering and fluid mechanics could all be regarded as the key components of the history of robotics (Hongshuai, 2021). According to Carey & Clarke (2019) the origin of robotics initiated back from the Greek theorist Aristotle's philosophies about computerised tools.

The Russian biochemistry professor Isaac Azimov (1940) predicted the moral and social insinuations that could result from the integration of automated tools in society. In 1940 Isaac Azimov proposed to organise the basic principles of how people should interact with the robots by introducing the three laws of robotics in 1942. The first law as quoted from the "Handbook of Robotics" (Azimov, 1942) asserted that: "A robot may not injure a human being or through inaction, allow a human being to be harmed". The second law: "A robot should obey the instructions allocated to it by people except where such commands would clash with the First Law". The third law: "A robot should shield its own existence as long as such defence does not battle with the First or Second Laws".

Moreover, the three laws of robotics by Isaac Azimov are still applicable in the current application of robotics and coding of different technological gadgets in education, science and engineering fields (Carey & Clarke, 2019). Figure 2.1 below shows the history, biggest developments and milestones of robotics up until the present day.

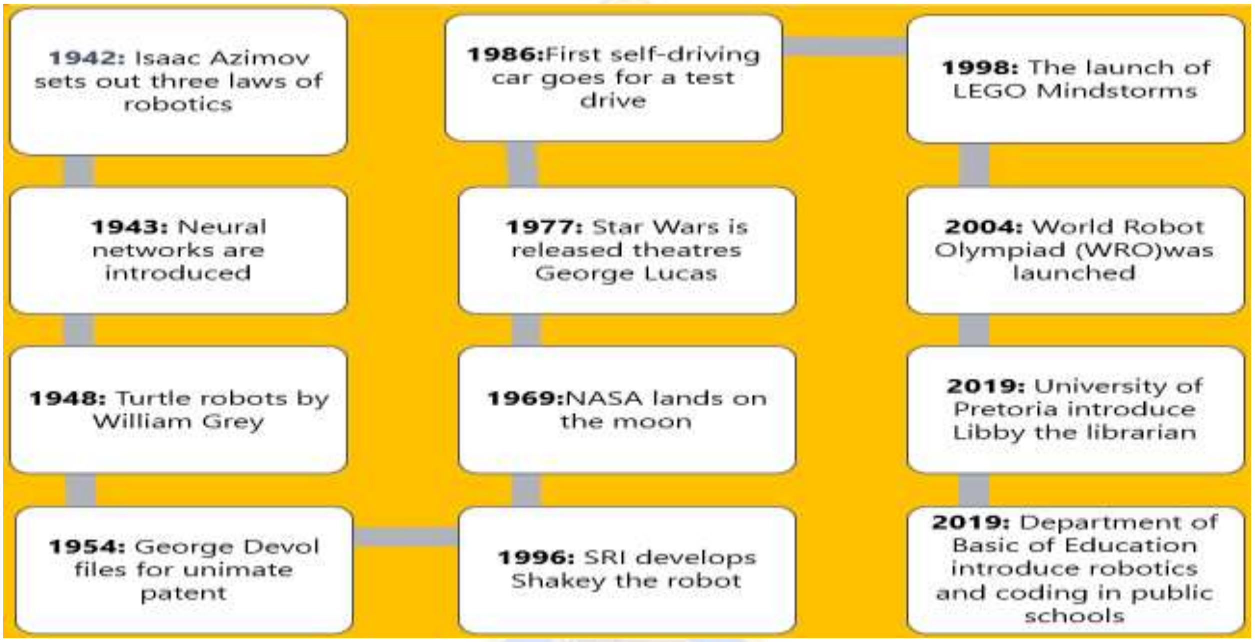

Figure 2.1: A brief history of robotics (Carey & Clarke, 2019; Department of Science and Technology, 2019; Stone, 2018; Veldman et al., 2021)

The history of robotics can provide insights into the development and evolution of robotics, shedding light on how it has transformed from a purely industrial application to a tool for educational purposes. Additionally, understanding the historical context can help researchers and educators identify any potential challenges or limitations that may arise when integrating robotics into the classroom. Studying the history of robotics enables researchers and educators to learn from past experiences and avoid repeating any mistakes or pitfalls that were encountered in the past. They can also gain a deeper appreciation for the advancements made in robotics over the years, which can be inspiring and motivating for students who are interested in pursuing careers in this field. Furthermore, understanding the historical context of robotics can also help educators tailor their teaching methods and curriculum to better engage students and provide them with a well-rounded education in robotics.

2.2.2 The state of robotics curriculum in the South African education system

The 2019 White Paper on Science, Technology and Innovation outlines the long-term strategies to give a way forward for the South African government to ensure that there is an increasing role of Science Technology and Innovation (STI) in a more effective and comprehensive culture (Department of Science and Technology, 2019). As a result, it emphasises utilising STI to assist South Africans to benefit from transformations such as fast technological developments and the important developments that are linked with the Fourth Industrial Revolution (4IR) (DST, 2019). In response to the 4IR South Africa has developed a coding and robotics curriculum to be integrated from grades R-9. According to the DBE (2021a), the curriculum will provide learners with knowledge and skills of coding and robotics and will prepare them for the 4IR.

The piloting of schools for coding and robotics for Grade R-3 has taken place in two hundred schools across all the provinces in South Africa whereas, in Grade 7 one thousand schools have been piloted (Writer, 2021). The piloted schools are provided with tablets and robotics equipment. According to DBE (2021a), there will be no additional instructors or coaches that will be employed to facilitate robotics in schools. As a result, some of the Universities such as the University of Pretoria, University of South Africa, University of Witwatersrand and non-governmental organizations have partnered with the DBE to offer educators training and technological services to administer coding and robotics (Veldman et al., 2021). Figure 2.2 and 2.3 below shows the number of pilot schools per province from grades R-7.

PILOT GRADE R -3

The Grade R-3 Pilot will take place in 200 schools across all provinces. The number of pilot schools per province are as outlined in the table below.

	PROVINCE	NO OF GRADE R -3 SCHOOLS
1	EASTERN CAPE	25
2	FREE SATE	15
3	GAUTENG	33
4	KWAZULU-NATAL	33
5	LIMPOPO	22
6	MPUMALANGA	17
7	NORTHERN CAPE	10
8	NORTH WEST	15
9	WESTERN CAPE	30
TOTAL		200

8

Figure 2.2: The number of pilot schools per province Grade R-3 (DBE, 2021a)

PILOT GRADE 7

The Grade 7 Pilot will take place in 1000 schools across all provinces. The number of pilot schools per province are as outlined in the table below.

	PROVINCE	NO OF GRADE R -3 SCHOOLS
1	EASTERN CAPE	111
2	FREE STATE	111
3	GAUTENG	111
4	KWAZULU-NATAL	112
5	LIMPOPO	111
6	MPUMALANGA	111
7	NORTHERN CAPE	111
8	NORTH WEST	111
9	WESTERN CAPE	111
TOTAL		1 000

9

Figure 2.3: The number of pilot schools per province Grade 7 (DBE, 2021a)

Due to the Covid-19 pandemic the initial strategies and plans to pilot robotics in public schools have been affected negatively in terms of time (Veldman et al., 2021). The DBE initially planned to start with the integration of robotics in 2020 by commencing with grades R-3 and followed by grades 4-6 in the 2021 academic year (DBE, 2021a). The piloting approach for grades 7-9 should have been done in 2022 (DBE, 2021a). Nevertheless, the drafted coding and robotics curriculum that was submitted to Umalusi for assessment and quality assurance was only approved and gazetted in 2021. These transitions led to a backlog and the DBE came up with new plans to pilot robotics in all schools across South

Africa. In 2021 the piloting process started with grades R – 7, followed by grade 8 in 2022 and lastly, grade 9 will be piloted in the 2023 academic year (Writer, 2021).

2.2.3 The coding and robotics curriculum grade R-9 in South Africa

The coding and robotics subject plays an essential role in a digital and information driven world by integrating technological skills and transmits these skills to handle day-to-day situations in the development of learners (DBE, 2021b). As a result, it is concerned with the enhancement and instilling of STEM related subjects in education. The subject coding and robotics in grades R-9 has been divided into five content areas. Figure 2.4 below shows the focus content areas in grade R-9.

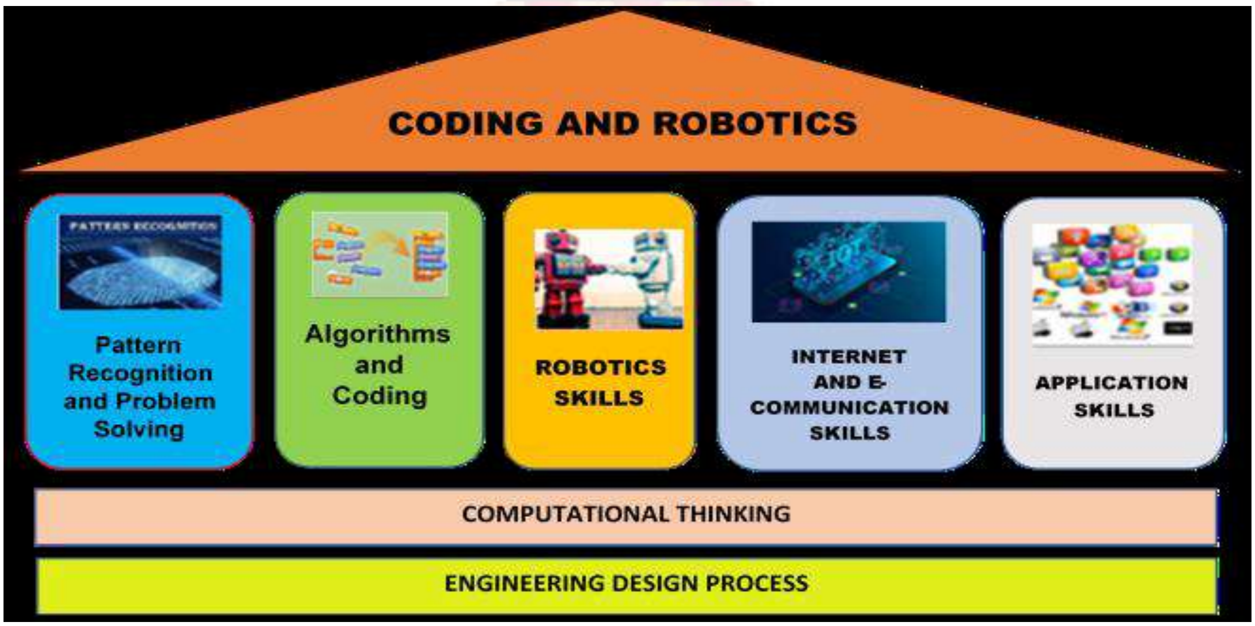

Figure 2.4: Coding and robotics focus areas Grade R-9 (DBE, 2021b)

The method of teaching and learning of the subject is constructed on the foundation of computational thinking and engineering designing processes (DBE, 2021b). The components of each content area are imparted in its strand but is also strengthened in other components. For example, pattern recognition and problem-solving constitutes certain abilities which still need to be established, but also creates the groundwork for algorithms and coding. Algorithms and coding are integrated to align a logical sequence that robots utilise, and the application skills show learners how to cooperate and communicate with different technological gadgets. Internet and e-communications focus on the implementation of technological gadgets that are imparted in application skills and integrate the same skills to direct and generate messages (DBE, 2021b). The content areas from grade R-9 are the same but they differ in skills and content knowledge per grade.

The coding and robotics curriculum is based on hands-on learning and involves the Practical Assessment Task (PAT), which are recorded as formal tasks and should be administered during the formal teaching and learning time according to the Annual Teaching Plan (ATP) (DBE, 2021b). The administration of informal tasks persists during lessons when learners are not engaging in PAT. Therefore, time allocation becomes one of the key elements when administering the lessons in the coding and robotics curriculum.

The pedagogical approach of teaching and learning robotics is based on the foundation of computational thinking. The integration of computational thinking is a fundamental skill in robotics to solve problems, create effective systems and innovative ideas. According to Chalmers (2018) there are four pillars of computational thinking which are as follows: decomposition, pattern recognition, algorithm design and abstraction. Figure 2.5 below shows the four pillars of computational thinking.

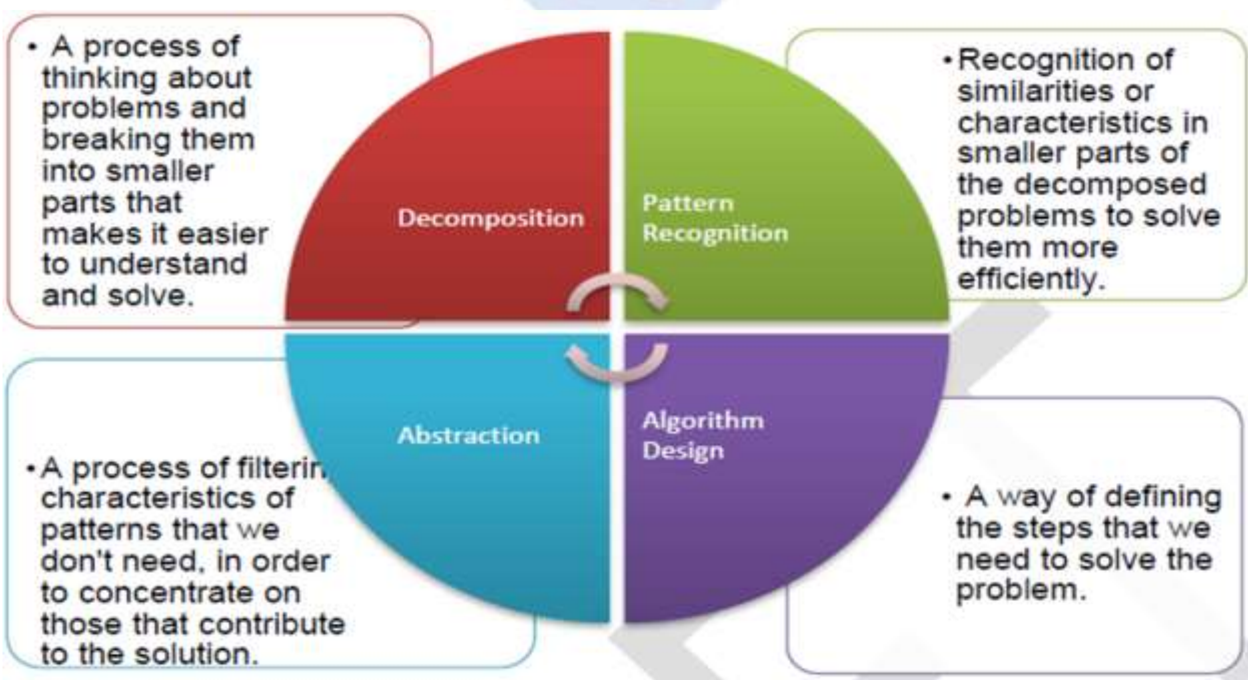

Figure 2.5: The four pillars of computational thinking (Chalmers, 2018)

2.2.4 Integration of robotics in public and private schools in South Africa

The introduction and development of new technologies necessitates the formation of innovative educational strategies that involves teaching and learning content and educational theories that are creative and appropriate to the current education system (Writer, 2021). As a result, this requires adjustments to influential philosophies to allow a successful 21st century period of teaching and learning. According to Zawacki-Richter and Latchem (2018) the utilisation of computers and technological devices such as overhead projectors, PowerPoint presentations, tablets, clickers, and smartboards are the normal use of technology in the current education system, specifically in private schools. The incorporation of robotics in teaching and learning to enhance the 21st century skills, has become a preferred pedagogical way in the current education system (Jung & Won, 2018).

The integration of robotics in public and private schools in South Africa shows a huge digital divide (Writer, 2021). Most private schools in South Africa introduced robotics into their curriculum from 2010, whereas the DBE piloted robotics in 2021 across all the nine provinces in South African public schools. This shows a huge difference in terms of the time frame of integration and not all schools that have been piloted are integrating robotics due to circumstantial issues such as limited resources, internet access, facilities and human resources (Writer, 2021). The piloting of schools involved schools, which are mainly situated in urban areas. During the piloting of robotics in schools the DBE provided the schools with robot equipment and tablets as part of the resources to be used to incorporate robotics (DBE, 2021b). They also provided teachers with training workshops after school hours in partnership with higher institutions to gain knowledge and develop skills in robotics (DBE, 2021b). According to Chisango and Marongwe (2018) afternoon training could contribute negatively on the time available for teachers to be fully engaged in learning, since they were facilitating their lessons during the day.

South Africa has many public schools, and some are rooted in deep rural areas whereby there are social and economic issues that should be taken into consideration and therefore the integration of robotics in those schools becomes a pipe dream to be achieved in the future (Chisango & Marongwe, 2018). This was also confirmed during the

Covid-19 pandemic lockdown whereby the method of teaching and learning was moved from physical teaching and learning to online learning (Mahaye, 2020). The public schools in rural areas suffered tremendously and even created a digital divide between urban and rural schools (Mahaye, 2020). Teachers from the rural areas were unable to use digital technology for online classes and struggled to adapt to online teaching due to a lack of adequate digital knowledge and skills (Mahaye, 2020). Some challenges experienced by teachers were associated with the lack of facilities to conduct online classes such as digital gadgets, access to data and lack of network and internet use especially in some rural areas where there is no electricity (Du Plessis & Mestry, 2019). In some of the rural schools, the integration of technology is at a minimal stage and is used for basic operations such as entering of learners' marks though the South African School Administrative and Management System (SASAMS) and typing and printing out of question papers. According to Du Plessis and Mestry (2019) some schools lack teachers who are technologically competent and able to support their fellow colleagues in integrating technology efficiently into their lessons.

In private schools the integration of robotics was initiated by offering teachers who specialise in technology, science and math, training and after training sessions teachers were assessed theoretically (Pather, 2020). The schools also have policies which give them guidance and direction on the implementation process and teachers have access to support sessions online which includes videos, tutorials and activities. In private schools they also employ human resources specifically for maintenance and technical glitches that may occur during the learning process with robotics (Pather, 2020). Hence, teachers only focus on facilitating their planned lessons according to the ATP efficiently without worrying about the maintenances of gadgets or any technical glitches. Whereas in public schools, teachers will be responsible for facilitating the lessons and solving technical problems such as software updates, poor connections and hardware malfunctions. A study by Chambers and Carbonaro (2018) shows that for the smooth running and integration of technology the school should have a qualified technician within the school premises to solve technical glitches.

Many private and former Model C schools in South Africa are already competing in the WRO competition. The WRO competition was first established in 2004 in Singapore. There were some private schools, which represented South Africa on an international level with robotics in countries like Malaysia, India and Russia, and some took part in Costa Rica to enhance their participation in robotics (ORT South Africa, 2017). According to Ntekane (2018) the integration of robotics in private schools is also influenced by positive parental involvement in terms of support, funding and availability. A study by Ates (2021) shows that parents have a crucial influence in encouraging their children's interest in the usage of technology or taking part in extra-mural activities by influencing them through both their own actions and the amount of inspiration they provide to them.

2.2.5 Robotics as an educational learning tool in the world

The integration of robotics in education has attracted many countries over the world with the aim of keeping the quality standard of their educational curriculum with the 4IR and preparing leaners for the digital world (You et al., 2021). However, the integration of robotics is not the same across all countries due to financial stability, affordability, politics and educational policies. For example, in Asia the implementation of technology and robotics as a learning tool is pervasive in high income populations whereby more innovative and digital forms of technological gadgets and broadband connectivity are available (Afari & Khine, 2017). As a result, learners and teachers in such populations become more advanced, knowledgeable and creative in how they integrate technology for teaching and learning. The presence of specialised human capital is one of the most important aspects for the growth and progression of science, technology and engineering in the world (You et al., 2021).

In developing countries such as Sri Lanka securing necessary capital is often considered to be the major obstacle for integrating advanced technological initiatives in education such as robotics (Lanka, 2021). A study by Gyamfi et al. (2022) shows a low literacy rate in Ghana within the people from rural areas, and the expenses of integrating technology/robotics in education such as hardware, software and strong network connections are perceived as an obstacle to integrate technology for teaching and learning. A study by Hbaci and Abdunabi (2020) asserts that in Libya teachers still perceive the utilisation of technology in education as a difficult task, and most learning institutions do not have adequate resources such as computers, accessibility to internet, and reasonable allocation of funds to improve teachers' technological skills in teaching and learning. Hence, the integration of advanced technological initiatives in education such as robotics is still a gigantic task to be achieved.

Policymakers internationally have largely acknowledged that the utilisation of technology in teaching and learning could have a positive impact on people coping in a universal economy by creating a trained labour force and enabling societal mobility (Qureshi et al., 2021). There has been an increase in interest from developing countries in knowing the way in which robotics, internet and subject matter are linked together to expand the knowledge and skills in science, technology and engineering (ORT South Africa, 2017). The old pedagogical approaches of integrating technology into education have been transformed and necessitates educational transformation globally (Qureshi et al., 2021). Robotics in developed countries such as Germany is perceived to be one of the key learning tools to enhance the minds of the young ones since they are open-minded which allows them to develop new information, and to show their creativity and improves critical thinking (Chaldi & Mantzanidou, 2021). The integration of robotics in Germany is based on the establishment of training workshops, learners' competitions and annual conferences.

2.2.6 Teachers' acceptance towards the use of robotics

Different learning institutions have changed swiftly by meeting the current demands of the digital world and aiming to promote 21st century skills (Tohani, & Aulia, 2022). Some countries afford resources, tuition and budgets so that they can supplement the implementation of technologies and prepare for the digital world and uplift the standard of their education. However, irrespective of all the determinations, several countries are experiencing the same predicament whereby teachers are not creating the best practice of the technology provided (Hamidi, 2016).

The integration of robotics creates a meaningful and hands-on learning approach, which benefits teachers and learners by simplifying concepts in Math, Science and Technology (Alam, 2022). According to Atman Ulsu et al., (2022) the focal point towards the use of robotics is based on teachers' beliefs, since the teachers are the human beings who incorporate the transformation in their teaching and learning practice. Furthermore, previous research by Nguyen et al. (2020) shows that the connection between teachers' attitudes and the utilisation of technology are vital.

Aaccording to Tengler and Sabitzer (2022) teachers' attitudes towards the integration of robotics are reliant on their experiences and they develop positive attitudes towards the use of robotics when they are integrating it more often in their teaching and learning. Tengler and Sabitzer (2022) assert that skills and knowledge gained from training can impact "perceived ease of use and perceived usefulness", which will result in impacting the attitudes of teachers towards the use of robotics in education.

2.2.7 Teachers' and learners' experience with the use of robotics

The perceptions of teachers and learners of the integration of technology are gained from their current and previous experience of using technology. According to Sangkawetai et al. (2018) field experience has a huge impact on the actual integration and implementation of technology in a learning environment. As a result, user experience is vital in determining the issues that might influence the acceptance of robotics in an educational setting by teachers and learners**.**

A study by Jaipal-Jamani and Angeli (2017) revealed that teachers lack self-efficacy and have misunderstandings towards the use of technology. As a result, this contributes to their inability to integrate technology in their respective classrooms and their actual experience. However, according to Lai (2017) some teachers believe that by just simply setting up technological tools for learners, effective teaching and learning will take place and there will be a huge educational transformation. Lack of training and technological skills has an impact towards acceptance of technology and will result in negative experiences**.**

The professional development for teachers in robotics is significant and provides teachers with skills and knowledge on how to teach robotics and how to integrate it into subject matter. According to Chambers and Carbonaro (2018) robotics teacher training equips teachers with necessary skills and information about robotics programming and creates positive experiences. The research by Samuels (2016) shows that having knowledge and skills about robotics encourages teachers to create scientific inquiries and their self-efficacy in both learning and teaching robotics and programming have improved after attending training in robotics. Moreover, the training had a positive impact on teachers' pedagogic philosophies towards teaching robotics and improved their STEM integration and emotional engagement.

The key role of the learning environment is to provide learners with skills and knowledge and prepare them for the future world (Denis & Hubert, 2016). Thus, learners' views about robotics should not be disregarded. However, according to Sangkawetai et al. (2018) teachers are accountable for equipping learners with knowledge in their respective classrooms with the objectives and aims of learners becoming knowledgeable and responsible citizens of the community. Learners' perceptions about the role of technology at school and their life outside of school can have an impact on their participation and curiosity. Hence, exploring learner's interests about technology and the impact it has on their day-to-day activities is a significant aspect, which teachers should take into consideration.

A study by Hamidi (2016) shows that learners who took part in the WRO, and study STEM in meaningful learning are capable of learning how things can be joined together to build a moving device that could be programmed. According to Bers et al. (2015) when learners are engaged in robotics, they acquire skills and knowledge on how to work as a team with their fellow classmates and to understand that in a team everyone has a role that serves the same purpose. Robotics creates a positive learning experience for the learners and provides numerous and different methods of acquiring skills and knowledge, in such a way that could not be replicated by traditional textbook based approaches (Jaipal-Jamani & Angeli, 2017).

2.2.8 Importance of robotics in education

Robotics in the educational setting provides learners with a chance to take part in problem-solving by participating effectively with their peers (Schina et al., 2021). Hence, the most significant and challenging topics in a subject could be learned through problem-solving (Schina et al*.,* 2021). Learning by solving problems permits learners to have optimistic perceptions towards the subject, uplifts their higher order thinking skills and supports them to intensely grasp the content knowledge by creating meaningful learning rather than rote learning (Schina et al*.*, 2021). According to Gouws et al. (2021) integrating robotics for problem-solving learning is an effective approach to instill the content knowledge and to allow learners to show their creativity and build their communication skills as they communicate with their peers.

During the learning process of robotics, learners work in groups, conduct investigations and collect data by brainstorming and create robots with their own designs. Learners also use elementary electrical apparatuses such as wires, insulators, sensors and wheels, to build a robot and integrate math by counting rotations, number of turns and angles and program their robot using computer software (Gouws et al., 2021; Schina et al., 2021). A study by Alam (2022) shows that robotics smartly and genuinely assimilates STEM in hands-on learning and can uplift learners' commitment, creativeness, collaboration, accurate investigation, collecting and evaluating information, solving problems and in-depth indulgence in subjects related to Science, Mathematics, Engineering and Technology.

Alam (2022) assert that the goal of STEM in learning robotics is not only about furthering learners' understanding of Physics, Math and Engineering subjects, but also to accommodate learners by giving them opportunities to promote and sustain permanent knowledge in STEM disciplines. Furthermore, according to Atman Uslu et al., (2022) robotics is an interactive device that constructs a stimulating educational setting, advances learners' perspectives and interest towards STEM disciplines and inspires them to take part in STEM projects and follow professions linked to STEM disciplines. According Tohani and Aulia (2022) states that robotics generates a thrilling and realistic setting, which accommodates learners with the opportunity to integrate facts and perspectives that they thought are ineffectual and impractical.

Robotics has received a lot of attention from educators and scholars as a respected educational tool to advance cognitive and communication skills for learners from kindergarten to higher grades, and to support education in Physics, Mathematics, Technology, Informatics and other school subjects (Tengler & Sabitzer, 2022). The core philosophies that support robotics in education are constructivism and constructionism

(Govender, 2021). Robotics builds an educational setting whereby learners can cooperate with their environment and work with real-world situations which results in a constructionist learning practice (Govender, 2021).

Constructionism supports learner-centred learning approach, practical and demonstration education whereby learners apply the knowledge or content that they are familiar with to obtain more facts and information (D'Angelo & Pellegrino, 2021). In some of the robotics lesson activities learners are working in groups, pairs and share ideas. In contrast, some of the activities are fully learner centred and the teacher just guides and keep control for learning to take place (Bih et al., 2020). When learners are fully engaged in an activity they connect information in what they have already know and what they are about to learn so that they can solve problems (Bih et al., 2020). For example when learners doing robotics programming activity they work collectively as a team and share ideas on how they will solve the problem. However, the aim is to observe the process in learning rather than the outcome of the project (Bih et al., 2020). Learners will have errors, mistakes but they will keep on trying until they have mastered the project.

Robots are valuable technological resources for teaching Math and Science; they can be utilised in classrooms for clarifying problematic topics since they grasp the attention of many children (Bers et al., 2015). According to Chambers and Carbonaro (2018) robotics is a suitable learning field to integrate current technological developments for learners and offers them advantages by energetically participating in the STEM spectrum and develops them to explore and contemplate in a constructivist way (Govender, 2021). A study by Tengler and Sabitzer (2022) showed that learners as early as Grade 1 can easily study significant Science and Math topics relevant to their curriculum by utilising LEGO resources. Denis and Hubert (2016) assert that robotics not only assists learners to study Science and Technology, but also meaningfully supports them to study sequencing that is significant for numerous fields, which involve reading, arithmetic, and basic life skills.

2.2.9 Factors that influence the use of robotics in education

The integration of robotics in education is demanding, costly, time consuming and requires adequate resources (Barreto & Benitti, 2012; Petre, & Price, 2014; Samuels, 2016). It necessitates additional time to design educational activities for workshops and solving technical glitches and puts pressure on teachers. A study by Chambers and Carbonaro (2018) shows that the main problematic issue that might obstruct educators from integrating robotics in education is teachers' enthusiasm and ability to learn. In contrast, a study by Lambert and Guiffre (2013) shows that the lack of sufficient educational robots and suitable software/hardware is the main stumbling block for integrating robotics in education for teaching and learning.

According to Eguchi (2014) the lack of technical support, educators' lack of self-reliance in their technological abilities, and their lack of understanding in creating the link between robotics and the subject matter are also key hindrances for educators to integrate robotics in education. Teachers need support with the resolving of hardware and software issues as well as technical maintenance (Eguchi, 2014). The technological support needs to be provided in the learning environment and it should be continuing practice, delivered during contact time and meet the needs of the educators. Lambert and Guiffre (2013) believe that the amount of work that teachers administer in their daily school schedule reduces their interest in engaging in new methodological approaches and new technologies.

Robotics as the current phenomena in the education field, which aims to equip learners with the 21st century skills and to promote STEM subjects, requires teachers to uplift their technological skills and competency (Samuels, 2016). Hence, in relation to preparing learners for the digital world, teachers play the most significant part by integrating robotics in their teaching and learning (Levin & Wadmany, 2011). Teachers' readiness and skills in integrating robotics are very crucial for the application of technology in education. Furthermore, teachers need suitable technological knowledge to incorporate technology and to be highly inspired to utilise it in their teaching and learning. A study by Chambers and Carbonaro (2018) supports this view by showing that teachers who went through robotics training which includes programming, assembling of robots and coding are extremely competent in integrating and linking robotics with their subject matter, as opposed to those that did not attend any form of training.

2.3 Theoretical framework

In this study, to identify and explore the acceptance of teachers and learners towards the use of robotics in education, the Technology Acceptance Model (TAM) by Davis (1989) was integrated. The TAM model encompasses different sections that demonstrate the process of technology acceptance by people who are using it; involving “behavioral intension, perceived usefulness, perceived ease of use and attitude towards using” (Lai, 2017). While perceived usefulness conforms to the level where the person considers the benefits of utilising a certain technology by improving the work presentation, perceived ease of use relates to the significance for technology to be accessible and friendly for people” (Dillion, 1996). TAM asserts that the integration of technology is controlled by the intention to utilise technology (Davis, 1989), and the intention is determined by individuals’ attitudes and perceived usefulness.

The model explores factors that lead people to accept or discard the use of various technological resources in a working environment. According to Davis (1989) perceived usefulness reflects people’s use of technology constructed from their beliefs of the technological abilities to elevate their work performance. Therefore, when the integration of technology tends to be beneficial and improving the productivity, people are more likely to integrate these technologies more often (Purba & Hwang, 2017). However, if the introduced technologies are not user friendly and challenging to integrate, negative attitudes towards using them will be stimulated and will influence the perceived usefulness, behavioural intentions and acceptance of the technologies (Purba & Hwang, 2017). People enjoy and promote using technologies that are easier to use and effortless when integrating them. This is regarded as the perceived ease of use.

The TAM is significant and most relevant to this study, since teachers’ and learners’ acceptance of the use of robotics is directly influenced by the four crucial principles of the model: perceived usefulness, external variables, perceived ease of use and users’ attitudes (Purba & Hwang, 2017). Figure 2.6 below shows the Technology Acceptance Model.

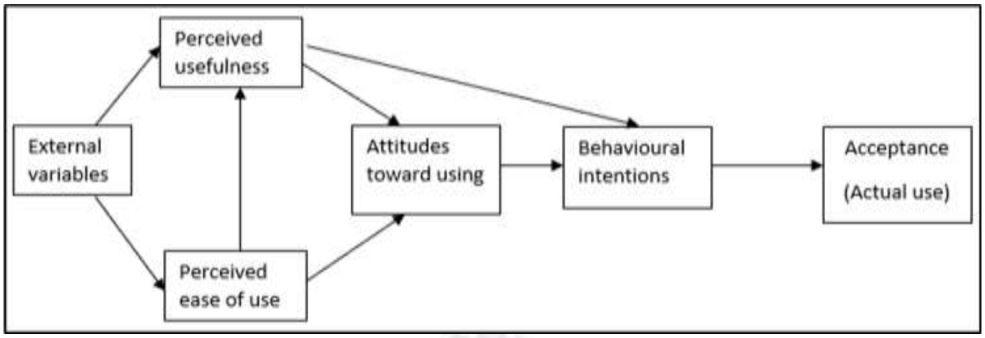

Figure 2.6: Technology Acceptance Model (Davis, 1989)

The objective of integrating robotics in education is fundamental for effective teaching and learning and maintains the core principles in the theory above like ease of use (Adams & Nelson, 2003). The intentions of teachers to integrate robotics are robustly affected by their perception of the ease of use and usefulness of the resources and apparent accessibility and deciding on their actual use of technology (Chau, 2009). The theoretical framework directed this study in exploring and identifying teachers' and learners' attitudes towards the use of robotics, as well as the external and internal challenges that influence the perceived usefulness and ease of the use of robotics.

2.4 Gaps in the literature

In responding to the 4IR the DBE has introduced the robotics and coding curriculum to develop learners for the digital world (Pather, 2020). However, the utilisation of basic technology in most South African public schools is still at a low level. Most schools do not have access to the internet, laptops and overhead projectors to facilitate teaching and learning with technology (Chisango & Marongwe, 2018). Hence, the method of teaching and learning still relies on traditional teaching methods with no integration of technology, and in some instances technology is integrated as a substitution method. However, when considering the advanced skills and depth of technological content in robotics, the public schools could face some challenges when integrating robotics. The initiatives of integration are based on a one size fits all approach, while schools have their own contextual factors to be considered based on their locations (Mahaye, 2020). Therefore, the DBE should primarily focus on the enforcement of the basic use of technology in schools and ensure that the majority of schools have adequate basic resources (Mahaye, 2020).

The piloting of schools to introduce coding and robotics across all the provinces in South Africa shows a gap between rural and urban schools (Mahaye, 2020). Most of the schools that have been piloted are from urban areas within the provinces and have basic technological resources, which raises questions of equal education for all. The schools that are based in rural areas that have been piloted are in the minority and they have underlying factors, which could not be avoided such as lack of electricity, internet connection, lack of classrooms, overcrowding and lack of basic resources (Du Plessis & Mestry, 2019). Therefore, the integration of basic technology in such schools becomes a pipe dream.

Robotics has received attention and praise from different countries around the world and most countries have adopted robotics in their education to enforce 21st century skills. The integration shows a huge gap between the developing and developed countries. The developed countries are far ahead in terms of the integration of robotics and different seminars and training are available for teachers to take part in. Learners participate in competitions and present their countries on an international level whereas some of the developing countries are still in the process of integration and the financial burden and affordability are experienced (Du Plessis & Mestry, 2019). Effective methods, strategies and programs on how the developing countries could be able to integrate robotics in their education should be drawn up.

When reviewing the literature, time constraints are regarded as one of the hindrances for integration of robotics. The literature highlights limited ideas and programs on how schools and teachers could manage their time to fully integrate robotics. Teachers' lack of technological skills tends to have an impact on the integration of technology (Amutha, 2020). Therefore, teachers should be provided with adequate training and resources to ensure effectiveness and conducive integration of robotics in their lessons. However, according to the DBE (2021a) no new coaches or teachers will be employed in schools to assist with the integration of robotics. Hence, there should be the establishment of applicable training that is based on teachers' individual, contextualised training needs for every step of robotics integration, as they may experience technical glitches, slow internet connections and no updating of software (Pather, 2020).

The importance of robotics in education is based on advancing learners' skills and knowledge to be competent and meet the demands of the digital world and 4IR. The 21st century skills are fully inculcated in robotics and learners are also enjoying working with their peers as a team. One of the key focuses for integrating robotics in education is to ensure that learners understand their school subjects such as physics, technology and math comprehensively. The literature does not show the direct link between robotics and subject matter. Moreover, the integration of robotics is mostly focused on the Science, Technology and Math spectrum.

2.5 Summary

In summary, the literature from this study demonstrates that the integration of robotics in education is demanding in terms of resources and requires proper planning. However, advanced and adequate training in technology should be administered for teachers so that they are able to integrate robotics. Teachers' attitudes and beliefs also play a role in holding them back to accept and integrate robotics in their teaching profession. This chapter discussed the existing literature regarding the teachers' and learners' acceptance of the use of robotics in the Intermediate Phase. Moreover, the Technology Acceptance Model (TAM) by Davis (1989) also underpins the study by showing that the experiences and attitudes of people affect their acceptance towards technology and integration.

Chapter 3: Research design and methods

3.1 Introduction

Chapter two of this study reviewed literature and presented the theoretical framework. This chapter discusses the methodology used in the study. Research methodology refers to the systematic approach and techniques used to conduct research. It encompasses the overall design, data collection methods, analysis techniques, and interpretation of findings. It provides a framework for researchers to gather reliable and valid data, ensuring the accuracy and credibility of their study. Additionally, research methodology helps in identifying the most appropriate research design based on the research objectives and questions, as well as guiding researchers in selecting suitable data collection methods and sampling techniques. This chapter served as a roadmap for how the study was conducted, providing a detailed explanation of the chosen research methodology.

This study used the interpretive research paradigm, which focuses on understanding the subjective meaning individuals assign to their experiences. Under the interpretive paradigm, the researcher adopted the qualitative research approach, to gain an in-depth understanding of people's experiences, beliefs, and behaviours. There is a variety of research designs that a researcher can employ in qualitative studies and the researcher chose to use the case study research design. The application of the case study research design in this study allowed for a deep exploration of the specific context of robotics education in these two schools. It provided valuable insights into the attitudes and experiences of both teachers and learners, shedding light on the effectiveness and impact of incorporating robotics into the curriculum. The population of the study entailed teachers and learners from grade four to six who are using robotics for teaching and learning. These were purposively sampled to gather in-depth knowledge of the acceptance of robotics for teaching and learning. Data was collected through semi-structured interviews, focus group discussions and field notes. The data was analysed thematically by using data analysis steps by Cresswell (2017). This study sought to ensure trustworthiness by putting measures to address credibility, dependability, transferability and confirmability. It also discussed the ethical considerations that were considered. For the purpose of this study, a qualitative research approach was integrated for collecting data, which involved personal experiences. Teachers and learners provided their experiences, opinions and feelings about their acceptance of the utilisation of robotics in the Intermediate Phase.

3.2 Research paradigm

A research paradigm refers to the framework or perspective that guides a researcher's approach to conducting a study. It encompasses the researcher's assumptions, beliefs, and theoretical foundations that shape their understanding of the research topic and guide their methodology (Kivunja & Kuyini, 2017). Understanding the research paradigm is crucial as it influences the choice of research methods, data collection techniques, and data analysis strategies. Researchers may adopt different paradigms such as positivism, interpretivism, or constructivism, depending on their ontological and epistemological stance towards knowledge and reality.

3.2.1 Ontology

Ontology is the idealistic school of work about reality. It is basically focused on the notion that is directly associated with truth, in particularly becoming, being, realism as well as the fundamental categories of reality and their associations (Al-Ababneh, 2020). However, for the purpose of this study reality is constructed on the assumption that truth involves a person's intellectual constructions of the things he/she connects within the environment (Ejnavarzala, 2019). Based on this study teachers and learners have their own perspectives or notions about the integration of robotics in education based on their experiences. Therefore, in order to get those facts or their perspectives the researcher gathered information directly from teachers and learners through different data collection strategies.

3.2.2 Epistemology

Epistemology is based on how things that are happening in the society can be acknowledged; how reality or information or physical principles, if they are real, can be revealed and make known (Al-Ababneh, 2020). As a result, it focuses on how individuals know that something is real or fact, the techniques for gathering the truth or reality, or how a person concludes their findings as real and authentic (Guyon et al., 2018). It assumes the connection between what is known and what is not known.

3.2.3 Socio-constructivism

Social constructivism is an interpretive scaffold where people look forward in recognising their being and construct truths, which are based on or related to their personal experiences (Creswell, 2017). Constructivism entails that truth is created through people's interactions. Therefore, knowledge is an individual creation and is socially and ethnically created. People construct their realities during their interactions with others and within their own environment (Guyon et al., 2018). Social constructivism was used in this study to collect information from the teachers and learners on how they perceive the utilisation of robotics in the Intermediate Phase. The researcher socialised with the learners and teachers, and as a result new ideas were formed through interactions.

Constructionism also supports the learning with robotics. Constructionism is a constructivist educational philosophy, which asserts that constructing knowledge occurs by building objects that are tangible (D'Angelo & Pellegrino, 2021). In robotics learners have an opportunity to create knowledge by building and programming robots with their peers using tangible objects and they become constructors of their own knowledge (Atman Uslu et al., 2022).

3.2.4 Interpretivism

Interpretivism focuses on understanding the subjective meaning individuals assign to their experiences and often involves qualitative methods (Junjie & Yingxin, 2022). This approach recognises that social phenomena are inherently complex and cannot be fully understood through objective measurement alone. Instead, interpretivism emphasises the importance of context, culture, and individual perspectives in shaping social reality (Junjie & Yingxin, 2022). Researchers using this approach often engage in in-depth interviews, participant observation, and the analysis of textual and visual data to gain a deeper understanding of the meaning and significance individuals attach to their experiences (Alharahsheh & Pius, 2020). By exploring the subjective aspects of social phenomena, interpretivism offers valuable insights into the complexities of human behaviour and social interactions (Alharahsheh & Pius, 2020).

By revealing how meanings are formulated, we can increase insights into the truths conveyed and thus develop our understanding of the entire phenomena. From this point of view a situation can be examined to give details about the approach in which individuals construct knowledge in their circumstances or the experiences they come across (Bouncken et al., 2021). When incorporating robotics for teaching and learning, different teachers and learners have different experiences, perspectives and attitudes. The researcher was able to explore teachers' and learners' acceptance of the use of robotics for teaching and learning. The application of interpretivism in this study allowed for a deep understanding of the subjective experiences and perspectives of teachers and learners in relation to robotics in education. By using qualitative research methods such as interviews and observations, the researcher was able to uncover rich insights into how individuals construct knowledge and engage with robotics in their specific educational contexts. This approach also acknowledged the importance of context and situatedness in shaping individuals' attitudes and experiences with robotics, highlighting the need for personalised and adaptable approaches to integrating this technology into teaching and learning.

3.3 Research methodology

The research methodology refers to the systematic and structured way in which the study was conducted, considering the specific objectives and research questions (Newman & Gough, 2020).

3.3.1 Qualitative research

Qualitative research focuses on intrinsic value, qualities, and characteristics of phenomena, rather than measurements or scientific inquiry (Gioia, 2021). This method aims to understand and represent truths as formulated by participants from an insider's perspective (Bouncken et al., 2021). It is a research method that focuses on gaining an in-depth understanding of people's experiences, beliefs, and behaviours. It involves collecting and analysing non-numerical data, such as interviews, observations, and textual analysis. Qualitative research allows researchers to explore complex phenomena that cannot easily be measured or quantified, providing rich and detailed insights into the underlying meanings and motivations behind human behaviour. It is particularly useful when studying subjective experiences, social interactions, and cultural contexts.

Qualitative research approaches involve studying phenomena in their natural settings and attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Bouncken et al., 2021). This type of research is often used to explore complex social and human issues, and it involves collecting and analysing non-numerical data.

A qualitative research approach was integrated for collecting data, which involved personal experiences. Teachers and learners provided their experiences, opinions and feelings about their acceptance of the utilisation of robotics in the Intermediate Phase. Teachers and learners were interviewed, and ethics were also taken into consideration by protecting the rights of the participants. Moreover, different data collection approaches and sampling methods were integrated to comprehend the underlying phenomena holistically. The researcher integrated this method because it explains why and how things occur. For example, some teachers may find it difficult to utilise robotics in the classroom for teaching and learning because of their fear of technology.

3.4 Research design

3.4.1 Case study

This study employed the case study. A case study is a method of investigation that explores contemporary phenomena from a real-life situation where the boundaries between phenomena and situations are not clearly defined (Hancock et al., 2021). Case studies involve in-depth investigations of a particular individual, group, community, or organization to understand complex real-life situations and phenomena. Multiple sources of support are used to gather data (Hennink et al., 2020). Therefore, a case study focuses on how individuals relate and interact with each other in a specific context and how they make sense of the phenomena being studied. This study examined teachers' and learners' attitudes towards the use of robotics. Data was collected by exploring the personal experiences of the teachers and learners when teaching and learning with robotics. The case involved two schools in Pretoria East that offer robotics as part of their curriculum, setting them apart from other schools.

The application of the case study research design in this study allowed for a deep exploration of the specific context of robotics education in these two schools. It provided valuable insights into the attitudes and experiences of both teachers and learners, shedding light on the effectiveness and impact of incorporating robotics into the curriculum. Furthermore, by focusing on schools that offer robotics as part of their curriculum, the study was able to compare and contrast their approaches with those of other schools, providing a comprehensive understanding of the benefits and challenges associated with robotics education in the Intermediate Phase.

A case study is an experiential methodology of investigation that investigates contemporary phenomena from an original actual life situation whereby the limitations amongst phenomena and situations are not obviously clear where numerous resources of support are utilised to gather data (Hancock et al., 2021). Therefore, a case study focuses on how individuals relate and cooperate with each other in a certain context and how they make sense of the phenomena being studied.

3.4.2 Purpose of inquiry

An exploratory research design was applied to gather a better understanding of the current problematic issue (Creswell, 2017). For this study, an exploratory research design was integrated to gather information as it wanted to understand how and why certain behaviours are happening. Teachers in schools have different experiences and views about integrating robotics in education. Therefore, the researcher wanted to know and understand the underlying phenomena by exploring the causes and effects. The exploratory research design was able to accommodate questions such as what and how that were also part of the research questions of this study.

3.5 Population and sampling

3.5.1 Population

Population refers to an inclusive cluster of people, organisations or items with the same characteristics that are the interest of a researcher (Leedy & Ormrod, 2015). The entire cohort of teachers and learners in the Intermediate Phase from the two identified schools were part of the population group of this study as they have common characteristics, which are of interest to the researcher. These individuals were chosen because they are involved in the use of robotics for teaching and learning and have been deemed to possess valuable information to answer the research questions. Additionally, the inclusion of both teachers and learners allowed for a comprehensive understanding of the research questions.

The population of this study consisted of all teachers and learners in the Intermediate Phase from the two identified schools. These individuals were chosen because they are involved in the use of robotics for teaching and learning and have been deemed to possess valuable information to answer the research questions. Additionally, the inclusion of both teachers and learners allowed for a comprehensive understanding of the research questions.

3.5.2 Sampling

Sampling is a method of choosing individual members or a portion of the population to represent the whole population (Leedy & Ormrod, 2015). The researcher used purposive and convenience sampling. In purposive sampling the participants are selected with a specific purpose. Convenience sampling is administered when participants are easily accessible and located in one geographic area to avoid time and cost constraints (Maree & Pietersen, 2016). Convenience sampling is one of the non-probability sampling approaches whereby the participants are selected within a cluster of individuals easier to collaborate or to contact (Bouncken, et al., 2021). This sampling method has been chosen based on the following reasons. Firstly, the participants are close to the researcher in terms of distance, which means transport money does not have to be used to get to them. Secondly, it will be much easier for them to participate since workshops and teacher training are attended together. Lastly, it could save time and the data will be collected very quickly and with less cost.

The researcher purposively sampled nine learners in the Intermediate Phase from the two identified schools. The schools were labelled as School A and School B. Three learners from School A represented Grade 4, three learners represented from School A represented Grade 5 and the other three learners represented Grade 6 from School B. Nine educators from the two identified schools were sampled. Three educators represented Grade 4, three educators represented Grade 5 and the other three represented Grade 6. The teachers were selected to represent different grades since the robotics activities differs from one grade to another and that will result in different experiences for teachers. In purposive sampling the researcher chooses individuals that take part in the research who have experience, wisdom or content about the research topic and study. On the foundation of the researcher's information of the people, he/she decides which participants must be chosen to supply the best and accurate data (Creswell, 2017).

Purposive sampling has been chosen for gathering data because the participants that have been selected are administering robotics in their respective schools. The learners also have background knowledge about robotics, and they take part in different robotics competitions. The selected participants were able to answer the research questions since they had experience. The integration of robotics is done in all phases; but differs in terms of curriculum and activities that are specified for a certain phase. Therefore, this study is specifically based on robotics in the Intermediate Phase. The teachers have the following characteristics: Firstly, they have knowledge about the application of technology in the classroom. Secondly, they have experience about integration of robotics in education for teaching and learning. Lastly, they are all qualified and professional educators as approved by the South African Council of Educators (SACE).

3.6 Data collection strategies

Data collection strategies are the approaches that the researchers utilise to collect data (Wellington, 2014). In this study, the researcher used semi-structured interviews, field notes, focus group interviews, documents and lesson observations as data-collection methods.

3.6.1 Semi-structured interviews

The semi-structured interview is a method of gathering data from participants whereby the researcher focuses on open-ended questions to allow the participant to give more details about their experiences and underlying phenomena (Bouncken et al., 2021). Semi-structured interviews hardly ever take prolonged periods and typically entail the contributor to fill in all groups of prearranged questions and enable questioning and explanation of the results (Hennink et al., 2020).

The researcher used the semi-structured interviews to gather data as it allows the participants to give in-depth knowledge based on their actual personal experiences, which is crucial in responding to the research questions. This is a very good method of gathering data as it ensures that questions are detailed and prepared in advance. Therefore, the participants and the researcher had a flow in terms of responding to the research questions. The researcher was able to make follow up questions as the conversation flowed. Moreover, the participants were interviewed individually, and all the information collected from the interviews was tape-recorded and later transcribed in the data analysis phase. The semi-structured interviews were integrated to gather information from the nine teachers.

The use of semi-structured interviews in this study allowed for a flexible and dynamic approach to data collection. This allowed the researcher to delve deeper into specific topics of interest and explore unexpected themes that emerged during the interviews. Additionally, the open-ended nature of semi-structured interviews allowed participants to provide more detailed and nuanced responses, providing a comprehensive understanding of their experiences and perspectives. The semi-structured interviews provided a platform for participants to share their personal stories and unique insights, adding richness and depth to the research findings. The interactive nature of the interviews also fostered a sense of rapport and trust between the researcher and participants, encouraging open and honest dialogue. Overall, the use of semi-structured interviews in this study proved to be an effective method for capturing the complexity and diversity of participants' experiences, ultimately enhancing the trustworthiness of the research. The semi-structured interviews were integrated to gather information from the nine teachers.

3.6.2 Field notes

Field notes refer to qualitative based data on behavioural observations and activities of the participants documented by researchers in the context or situation that they are investigating (Phillippi & Lauderdale, 2017). The notes are planned to be interpreted as proof that provides meaning and support in the accepting or acknowledging of the observable behaviours. The researcher used field notes to capture data that cannot be recorded on the voice recorder and noted the participants' non-verbal reactions during the interviews as these also play an important role when collecting data and shows the actual truth or experiences of the participants.

3.6.3 Focus group interviews

A focus group interview is a method used to collect data through group interaction (Maree & Pietersen, 2016). This approach is based on the idea that group interaction can lead to a wider range of responses, bring out overlooked aspects of experience, and help participants feel more comfortable sharing information (Maree & Pietersen, 2016).

The researcher utilised focus group interviews to gather information from Intermediate Phase learners who may have been hesitant to participate individually due to their age. Focus group interviews allowed learners to build on each other's ideas and comments, resulting in more detailed perspectives than individual interviews. This collaborative approach also fostered a sense of community among the participants, as they were able to connect with others who shared similar experiences and challenges. Additionally, the focus group interviews provided a platform for participants to discuss and explore topics in a deeper and more meaningful way, as they could bounce ideas off each other and engage in lively discussions. Overall, the use of focus group interviews proved to be an effective method for gathering rich and diverse insights from Intermediate Phase learners.

3.6.4 Observations

Observations refer to the use of human sensory systems such as ears and eyes to examine and record the behaviour in a fieldwork (Cohen et al., 2018). The researcher observed the learners' behaviours based on their interactions, confidence and attitudes during the robotics lessons. To fully comprehend the underlying phenomena, teachers were observed in terms of their methodological approach, skills and knowledge to facilitate their lessons in robotics. The researcher managed to observe the lessons in the natural setting of the participants without interfering with the lessons. The researcher used Notebook to record and took notes while observing the lesson. Data collected through observations are crucial to this study since the information is based on the actual scenes and actions. Information that might not have been collected through the interviews was gathered through observations.

3.7 Data analysis

Data analysis is of utmost importance in research as it allows researchers to make sense of the collected data and draw meaningful conclusions an insights (Lester et al., 2020). It refers to the process of examining and interpreting the collected data. It involves organising, cleaning, and transforming the data into a format that can be easily analysed (Lester et al., 2020). It helps in identifying patterns, trends, and relationships within the data, enabling researchers to address their research questions effectively. Additionally, data analysis also helps in ensuring the trustworthiness of the findings by providing a systematic and rigorous approach to interpreting the data (Mezmir, 2020)

Qualitative data analysis types include thematic analysis, content analysis, and discourse analysis (Mezmir, 2020). Thematic analysis involves identifying patterns and themes within the data to gain insights into the research questions (Janis, 2022). Content analysis focuses on systematically categorising the content of the data. Discourse analysis examines the language and communication used in the data to understand social and cultural meanings (Janis, 2022). These types of qualitative data analysis can provide rich and nuanced understandings of the research topic (Morgan & Nica, 2020).

This study adopted the thematic analysis to analyse data due to its ability to identify and analyse patterns and themes within the qualitative data collected. By using thematic analysis, the researcher gained a deeper understanding of the underlying concepts and ideas related to the implementation of robotics in the classroom. This analysis method allowed for a comprehensive exploration of the data, providing valuable insights into the experiences and perspectives of both teachers and learners involved in robotics education. Content analysis is a methodical tactic to qualitative data analysis that classifies and summarises the content of the message (Creswell, 2017). After gathering data, it is important to analyse it and look at the difference and similarities so that we can reach conclusions. Content analysis was used to summarise the data collected and draw up conclusions based on the findings. The following data analysis steps by Creswell (2017) were used to analyse the data:

- The data were organised and large components were broken into smaller sections.
- Patterns or themes in the data were recognised and categories created.
- Data was combined.
- A summary of the information was obtained.

3.8 Methodological norms

In a qualitative study, the researcher must clearly describe how the data was analysed to guarantee and fulfil the trustworthiness of the research (Hennink et al., 2020). There are four criteria that should be followed by a researcher in assuring the trustworthiness:

3.8.1 Credibility

Credibility in research refers to the extent to which the findings accurately represent the participants' experiences and perspectives. To enhance credibility, researchers can use methods such as member checking, where participants review and confirm the accuracy of their data. Additionally, researchers can employ peer debriefing, where other experts in the field review and provide feedback on the analysis process. These steps help ensure that the findings are trustworthy and reliable (Hennink et al., 2020).

The researcher's certainty about the legitimacy and authenticity of their findings is known as credibility (Creswell, 2017). Credibility was established by quoting participants about their experiences, asking clear questions linked to the study's theoretical framework, and allowing participants to share their experiences without judgment or prejudice. The researcher also employed member checking, where participants were given the opportunity to review the findings and provide feedback. Additionally, the researcher maintained a reflexive journal to document any biases or preconceptions that may have influenced the study. This transparency and self-awareness further enhanced the credibility of the research findings.

3.8.2 Dependability

Dependability is the likelihood that research findings can be replicated by other researchers and that the information will be consistent (Maree & Pietersen, 2016). The researcher recorded all information and used a notebook for note taking, data analysis, and the final report. They worked with the supervisor and co-supervisor to review the data collection and analysis process, and the research study results, to ensure accuracy and support from the collected data. This level of collaboration and scrutiny enhances the dependability of the research findings. Additionally, the researcher followed established research protocols and used reliable measurement instruments to minimize errors and increase the chances of replication. The thorough documentation of the research process and the use of clear and transparent methodologies further contribute to the dependability of the results. These measures strengthen the confidence in the accuracy and consistency of the findings, making them more reliable for future researchers to build upon. Dependability is the level or chances that the research findings can be recurring or repeated by other researchers and the information will be constant (Maree & Pietersen, 2016). The researcher ensured that all information was recorded and used a notebook to take notes, analyse data and create a final report. The researcher worked in consultation with the supervisor and co-supervisor to review the process of collecting and analysing data, and the results of the research study. This was initiated to confirm the accuracy of the results and to guarantee that they were supported by the data collected.

3.8.3 Transferability

Transferability refers to whether the information gathered can also be used or is applicable to other research studies (Maree & Pietersen, 2016). The researcher's findings are useful for all schools that offer robotics as part of their curriculum and to all schools that are looking forward to integrating robotics in their curriculum. The study also adds knowledge to the existing literature and can be supportive to everybody interested in the questions addressed by the researcher.

3.8.4 Confirmability

Confirmability is an extent of a neutral stance in data gathering based on participants' answers and there is no bias (Maree & Pietersen, 2016). The researcher ensured confirmability by capturing more data during the data collection process to decrease situations whereby personal interpretations were being applied. The researcher clearly outlined the purpose of the research and allowed the participants to be actively involved and ask follow up questions where necessary. The participants had an opportunity to confirm the interpretation of their own words.

3.9 Ethical considerations

Ethics in research is significant as it ensures that the researcher proceeds in the right direction and takes correct measures when conducting research (Drolet et al., 2023). Firstly, the researcher applied for ethical clearance at the University of Pretoria before conducting the research. The research was only conducted after receiving the ethical committee's approval. Secondly, the researcher made an application to the Gauteng Department of Education (GDE) before conducting the research and requested permission from the school principals. Lastly, all the participants involved, such as parents and educators, were informed by means of consent letters and assent forms for learners. The researcher wrote the consent letters and assured all participants that no harm or injury would occur during the research process.

All the participants were informed in writing that their information or details would be kept private and confidential, and pseudonyms were used to protect and respect the real names of the participants from publicity. Their actual names were not used for publishing the data gathered to protect their confidentiality. The participants were also assured that their participation is voluntary, which simply means that they are not forced to be part of the research and they can withdraw any time when they feel like they cannot take it anymore and no actions will be taken against them (Drolet et al,. 2023). The researcher ensured anonymity by not requesting personal information from the participants such as their home address and identity numbers. The researcher focused on the main purpose of the research and adhered to all ethical considerations.

3.10 Conclusion

This chapter outlined the epistemological perspective of the study and different data gathering approaches. Teachers and learners were also selected purposively based on the advantages of nurturing the research with information to comprehend the underlying phenomena. Teachers and learners are the primary source of information for this study as they have provided their personal experiences about their acceptance towards the use of robotics in the Intermediate Phase.

Chapter 4: Data analysis and findings

4.1 Introduction

This chapter outlines the analysis of data, which was collected from the two identified primary schools in the East of Pretoria. The researcher used the semi-structured interviews as the primary tool to collect data from teachers, followed by the focus group interviews to collect data from learners. Field notes and lesson observations were also integrated. The data was analysed thematically by using data analysis steps by Creswell (2017). The researcher marked all the recurring ideas from the semi-structured interview responses and arranged the data in thematic way. The data anyalsis steps by Cresswell (2017) were implemented in the following order:

- The data were organised and large components were broken into smaller sections.
- Patterns or themes in the data were recognised and categories created.
- Data was combined.
- A summary of the information was obtained.

4.2 Data collection

4.2.1 Background of the participants

Nine learners and nine teachers from two different schools were purposively sampled as participants for this study. The schools were labelled as School A and School B. In School A six learners and six teachers were sampled to represent Grade 4 and Grade 5. In School B three leaners and three teachers were sampled to represent Grade 6. The participants (teachers and learners) consisted of both male and females from different age groups. All teacher participants were asked about their demographic information such as number of years in teaching, subject specialisation, age and gender. Pseudonyms were used to protect the identities and confidentiality of the participants. The biographical information of teachers is tabled in Table 4.1 and the biographical information of learners in Table 4.2.

Table 4.1: Demographics of teachers' participants

Pseudonyms	**Gender**	**Age**	**Subject(s) specialization**	**Number of years teaching**
Mokoena	Female	35	Math	7
Nkuna	Male	36	Natural science and Technology	8
Marklye	Male	37	Math and English	9
Karen	Male	31	Natural Science and Technology	6
James	Male	32	Math	8
Kathy	Female	40	Math and Natural Science	13
Kim	Male	41	Math	10
Sarah	Female	35	Math	6
Tom	Male	32	Computer Application Technology	5

Table 4.2: Demographics of learners' participants

Learner participants	**Gender**	**Age**	**Grade**
Participant 1	Male	11	5
Participant 2	Male	12	5
Participant 3	Female	11	5
Participant 4	Male	12	6
Participant 5	Female	12	6
Participant 6	Female	11	6
Participant 7	Male	10	4
Participant 8	Female	9	4
Participant 9	Male	10	4

4.2.2 Data collection process

The researcher implemented face-to-face interviews with the participants at their places of interest (classrooms and staffrooms). The inputs/opinions of the participants were written down in a journal and a voice recorder was used to record the conversations. The participants were informed prior to the interviews through emails and telephonically about the schedule of their interviews.

The researcher initially introduced himself to the participants and explained the purpose of the interviews. All the participants were assured that their information would be kept confidential, and that it was only for research purposes and their participation was voluntary. The teacher participants were asked 12 questions each and the interview took about 25 to 30 minutes per participant. The learner participants were divided into two groups and each group was asked nine questions, which took about 15 to 20 minutes.

4.3 Data analysis

4.3.1 Semi-structured interviews

a) Technological training and impact on teaching

The researcher posed this question to the participants to get their background information in terms of their expertise and experience of teaching and learning with technology. Participants were able to reflect on their training and how technology influenced their teaching.

Most of the participants had received technological training as part of their teacher professional development. The training influenced their teaching and learning positively, since they integrated technology to facilitate their lessons, administration and integrate robotics as part of learning with technology. Mokoena asserted: *"In my first year at varsity a computer course was one of the fundamentals. I acquired both the practical and theoretical part of using technology. Technology education had a great impact on my career as a 21st century educator and as a Maths and Science educator".* James also highlighted that he received technological training at university level.

Nkuna highlighted: *"The technological training has impacted positively in my work since I am competent in using SASAMS to capture marks, to design time tabling, year plans,* *management plans".* The technological training motivates teachers to administer meaningful and interesting lessons by integrating technology and assists them to execute their day-to-day activities within their learning institution. Karen stated: *"The technological skills are significant as an educator, recently Covid-19 attacked us spontaneously which impelled us to operate online through ZOOM, Microsoft Teams, communication with parents and all other basic school rudiments".*

b) Experiences in using robotics in the Intermediate Phase

The majority of the participants highlighted that they had nurtured skills and knowledge with robotics since they had been teaching it for a couple of years and participated in the World Robot Olympiad (WRO). According to Kathy: *"Learning with robotics is like driving a car the more you drive it, the more you get exposure and experience".*

Marklye asserted: *"I gained more experience through YouTube videos, and I attended various workshops offered by World Robotic South Africa (WROSA) through smart cities challenge which allows coaches, teachers and learners who participate in competitions to learn and acquire skills using full equipment".* However, teachers have different experiences of using robotics in the Intermediate Phase as some have their own way of outsourcing information to uplift their knowledge in robotics. Nkuna indicated: "*I have four years' experience in coaching Lego Robotics in the Intermediate Phase and participating in WRO competitions".*

The integration of robotics in the Intermediate Phase plays an essential role in the curriculum delivery by enhancing the technological skills and knowledge for teachers and learners. According to James: *"Robotics motivates Intermediate Phase learners to reach their maximum potential, they strive to lead, learn and master skills on their own. This promotes independence among Intermediate Phase learners".*

Within the sphere of educational technology, the role of robotics integration has been recognised as a critical element for augmenting the learning experience. An educator, named Nkuna, made a notable statement: "*The use of robotics in the intermediate phase is useful. We should always be updated with newly introduced technology as we are in the Fourth Industrial Revolution. Robotics can foster collaboration, creativity, and* *adaptability in learners, providing them with a strong foundation for their future careers*." This remark is in line with Eguchi (2016) research, which posits that robotics in education cultivates essential skills for the 21st century, such as critical thinking and collaboration. Furthermore, Afari, & Khine (2017) underscore the significance of educational robotics in enhancing active engagement and problem-solving skills in students. These scholarly works support the idea that educational robots are effective tools for developing abilities in Mathematics, Science and Technology, a concept also highlighted by Gunal (2019) who stresses the transformative role of robotics in the era of the Fourth Industrial Revolution. Hence, the integration of robotics, as pointed out by Nkuna, is consistent with the extensive academic dialogue on the importance of technological progress in contemporary educational methodologies.

c) The importance and usefulness teachers find when using robotics for teaching and learning

To examine what influences teachers' acceptance of robotics in the Intermediate Phase for teaching and learning, teachers' points of view on how effective and useful robotics is needs to be explored. The importance and usefulness of robotics for teaching and learning will determine their future use and sustainability in the education system.

All the participants recommended and valued robotics as an important educational tool to enhance technological skills for teaching and learning. The participants believe that through robotics learners can develop their career path in STEM related careers at an early age. According to James: "*We are now in a 21st century and globalisation has transformed every aspect of our lives. Our learners should acquire 21st century skills such as the utilisation of ICT, collaboration, communication, creativity, analytical thinking from primary school".*

Some of the participants also asserted that the integration of robotics in the Intermediate Phase has a huge influence on building learners' academic performance in Math and Science. According to Karen: *"Robotics integrates Mathematics, Science and Technology and learners acquire engineering skills in building a robot and programming it at an early age".* Nkuna and Kathy shared the same opinion. Kathy further asserted: *"It is important to integrate robotics in the Intermediate Phase for teaching and learning because robotics* *promotes independence, problem solving skills, abstract thinking and improves learners content knowledge in Mathematics, Science and Technology (MST).*"

To some of the participants the integration of robotics in education has a huge impact on developing the country for a better future in terms of job creation and economy. According to Mokoena: *"The integration of robotics will allow the education system to produce entrepreneurs who will not contribute to the rate of unemployment but who will create jobs for their fellow citizens. Our children will not wait for hand-outs from government, they will stand up and utilise their skills of robotics to salvage our economy".* Some of the participants perceive robotics as a weapon to strengthen and create relationships with other countries since learners can travel abroad to participate in competitions. According to Marklye: *"Robotics enables learners to solve real life challenges and they will be able to collaborate with their peers not only in South Africa but also internationally and build partnerships".*

The challenge of improving South African learners' performance in Math and Science, as indicated by international assessments like TIMSS, positions the integration of robotics in education as a viable solution. Marklye provided an insightful view on the potential of robotics: "*Robotics will enable our learners to be open-minded, creative problem solvers, entrepreneurs, to have good written and communication skills, to work well independently and in a team, and this will boost their performance in Maths and Science...*". This perspective corresponds with Zhang & Zhu (2022) findings, illustrating that robotics can bolster critical thinking and problem-solving abilities, essential for subjects such as Maths and Science. Supporting this view, Tzagkaraki et al., (2021) present evidence showing how robotics enhances creativity and collaborative skills in learners, significantly contributing to their academic success. Additionally, research by Robinson and Kapoor (2020) on the impact of robotics in developing nations highlights its role in addressing educational disparities, especially in challenging subject areas. Therefore, the adoption of robotics, as highlighted in the interview, represents not just a technological advancement but also a strategic method for enhancing student outcomes in vital academic subjects.

d) Robotics ease of use in the Intermediate Phase

Four of the participants felt that the use of robotics is not easy and requires constant training and practise. The participants received various training sessions from different service providers. However, they believe that robotics is not plug and play and one should always revisit the manual and online tutorials to administer lessons and prepare thoroughly. According to James: "*Robotics requires constant training and practise for one to be able to build and effectively program the robot".* Nkuna highlighted that "*one of the key aspects which make the robots not easy to use is that it can operate many activities in one game or race. Hence, one should know all the programs and codes to program the robot such as move steering, touch sensor, move block, colour sensor, etcetera".*

Two of the participants felt that it is simpler for them to integrate robotics and they also believe that robotics requires enough time since it is based on a trial-and-error approach. According to Kathy: *"Robotics activities are different and is not one size fits all and in order to be fully competent one should have patience and be innovative".* Mokoena asserted that *"the online videos and different training he attended make things easier for him when teaching robotics".* Mokoena further highlighted that the involvement of learners to do the robotics activities as a team make it easier for them to utilise robotics.

The ease of use of robotics seems to be a challenge to some of the participants and requires more time for them to complete some of the programs. Karen and Marklye shared the same opinion. Marklye stated: *"Sometimes you will take more time programming the robot, counting the number of rotations on the mat and when you test the robot on the mat it does something different then you have to go back again and restart the programming".* Karen further highlighted that *"assembling of robots according to the game specification could be difficult sometimes since some of them requires higher knowledge of robot applications".*

In contemporary discussions on educational methods, robotics has been identified as an instrumental resource for augmenting various cognitive abilities in learners. A statement by Mokoena emphasised the importance of robotics in education: "*Yes, it is important to integrate robotics in the intermediate phase for teaching and learning because robotics promote independence, problem-solving skill, abstract thinking, and improves math and* *technology learners' performance in the classroom.*" This viewpoint is supported by Anwar et al. (2019) argument that robotics in education substantially aids in the development of problem-solving skills and abstract thinking. In addition, Anwar et al. (2019) have noted the beneficial impact of robotics on student performance in math and technology, mirroring the sentiments expressed in the interview. Jawaid et al. (2020) study also demonstrates how robotics education encourages independence among learners, prompting them to initiate and seek innovative solutions. Consequently, the integration of robotics in the intermediate phase of education, as suggested by the interviewee, is backed by an expanding corpus of research that underscores its advantages in enhancing key cognitive and academic skills.

e) Teachers' attitudes towards the use of robotics

All the participants are positive about the integration of robotics for teaching and learning. The participants believe that robotics is very important for the education system; it should be officially integrated in all schools as a subject and it creates better opportunities for the learners. According to Kathy: *"I fully support the use of robotics for teaching and learning because it advances our learning and teaching skills to meet the needs of technology integration. Modern life is based on advanced technology which urges people to learn using technology to survive the current and future system".*

The participants' attitudes are based on the possibilities they perceive robotics could add to the education system and the skills and knowledge learners attain in robotics. According to James: *"Robotics simplifies teaching and learning; we can do a lot better when we take robotics to our classrooms particularly that it encourages problem identification and problem solving".* Mokoena highlighted that integration of robotics in education provides multiple skills in our education system and gives educators an opportunity to uplift their skills in technology.

f) Learners' and teachers' perceptions towards the teaching and learning of robotics

The participants were questioned about their colleagues' and learners' perspectives in relation to the integration of robotics for teaching and learning. There are different perspectives concerning the integration of robotics for teaching and learning. Some of their colleagues believe that robotics is just for fun and entertainment for learners to learn with technology. However, all the participants highlighted that learners are very positive about robotics, and they are always looking forward to learning more when they take part in robotics.

The perceptions of robotics are based on individuals' background or experience with technology. According to Mokoena: *"My colleagues are sceptical about robotics; this is because most of them do not have intense training of ICT in Education and Computer Applications Technology. Although they are positive about teaching robotics and advancing in technology in our classrooms, they are still sceptical about them being the curriculum drivers of robotics".* Karen and Kathy shared the same opinion. Kathy stated: *"My colleagues' perceptions towards robotics are not impressive because only a few engage in robotics learning systems while most don't even attend workshops".*

The participants believe that learners' perceptions towards the integration of robotics for learning are quite impressive and they enjoy working as a team. According to Nkuna: "*Learners perceive robotics as the way to go due to their exposure of technological devices and they are quick to learn and manoeuvre around the gadgets".* In addition, Mokoena stated*: "Most learners in the Intermediate Phase join the afternoon robotics lessons and every learner wants to be part of the competition. Learners are interested in doing robotics and learn using robotics, they like to use gadgets and access the internet as it makes their learning easier".*

g) Benefits/ opportunities of robotics in the Intermediate Phase

All the participants highlighted that the integration of robotics in the Intermediate Phase has great benefits and opportunities for the learners. Robotics as an educational tool prepares learners to become future engineers and teaches them independence at an early age. According to Marklye: *"Robotics improves teachers' and learners' competency. It promotes a stimulating learning environment, introduces learners and teachers to technology. Helps to integrate technology into the classroom. Secures future jobs and careers".*

The participants believe that robotics encompasses all learning capabilities such as reading, writing, drawing, calculating, theoretical thinking, problem-solving skills and critical thinking as well. According to Nkuna: *"Robotics enables our learners to be open minded, creative, problem solvers, to have good written and communication skills, to work well independently and as a team"*. In addition, James stated that *"robotics puts teachers and learners on a global scale, we are able to compete, access and be in line with the global trends".*

The integration of robotics into classroom environments is being increasingly acknowledged as a crucial component of contemporary education. An educator named James stated, "*The use of robotics for teaching and learning is essential, and we should promote it...*" This viewpoint finds support in Michalec et al's (2021) work, which highlights the advanced knowledge and skills derived from robotics, aligning with the evolving requirements of the 21st century educational framework. The integration of technology in classrooms, as mentioned in the interview, is echoed by Jawaid et al. (2020), underscoring the importance of technological tools in improving the learning environment. Hew et al. (2019) have shown how robotics enables the practical application of theoretical knowledge, thus rendering learning more engaging and effective. The integration of robotics not only signifies technological progress but also represents a strategic pedagogical approach that enhances the educational experience for both educators and learners.

h) Challenges when integrating robotics for teaching and learning

The challenges of integrating robotics for teaching and learning differs based on the school context. Learning institutions may have access to various technological resources. However, there are numerous internal and external challenges that could influence the smooth integration of technologies in classrooms. The internal challenges are based on individuals' beliefs, perceptions and personal preferences about the integration of technology, which are mainly determined by the ease of use and usefulness (Foss & Rasmus, 2019). Moreover, the internal challenges are barriers, which are based within the school environment, whereas the external challenges are concomitant with hindrances outside the school environment like any support originating from the educational authorities (Foss & Rasmus, 2019).

The following factors have been highlighted and categorised under internal challenges: lack of support and motivation from the SGB, SMT and co-workers and time allocation for robotics lessons. The following factors are regarded as external challenges: unscheduled power cuts during robotics lessons, cost and affordability of robotics equipment, lack of technological resources and lack of continuous training for teachers. The internal and external challenges both have a negative impact on the effective teaching and learning with technologies, and for the successful integration of technology they should all be examined. For instance, when teachers are fully trained and supported for integration of technology, they will have positive attitudes and perspectives towards the utilisation of technology.

Some of the participants highlighted that there are some challenges, which could not be avoided when integrating robotics such as few allocated resources, lack of training and time allocation for robotics lessons. According to James: *"Lack of teaching and learning support materials for robotics such as internet access, gadgets, table with mat route and time assigned by the school are major challenges when integrating robotics"*. Most of the participants highlighted the issue of time as one of the major challenges since robotics requires learners to work as a team which necessitate more discussions and planning.

The issue of cost and affordability was also highlighted as one of the major obstacles when integrating robotics for teaching and learning. According to Nkuna: "*The robotics teaching and learning support materials are very expensive for example just a single set of Lego Mindstorms cost about R6 000 and it could only accommodate about four learners and one robot which costs about R4 000".* In addition, Mokoena highlighted that "*sometimes learners have to share some of the robotics materials which delays the process of teaching and learning"*.

The participants also highlighted that the lack of support from their colleagues, School Management Team (SMT), parents and School Governing Body (SGB) influence the integration of robotics for teaching and learning negatively. According to Marklye: *"The SGB is responsible for governance and LTSM procurement and they do not purchase* *enough materials for robotics which inconveniences the smooth running of robotics".* However, Kathy highlighted that *"as part of SMT, I also take the blame because during needs analysis we disregard robotics on LTSM and put our hopes on sponsors".* Moreover, the issue of continuous and consistent training for teachers also raises a big concern since most of the participants believe that robotics is not a fixed curriculum or content like textbooks. Hence, more continuous training should be provided for educators.

The two identified schools are well resourced and in a very conducive environment for teaching and learning. However, they do not have power backup during load shedding which inconveniences robotics lessons since they require overhead projectors, use of the internet, laptops and EV3 robots. According to Nkuna: "*Load shedding disrupts the robotics lessons, and we end up doing activities that we did not plan for on that particular day*".

4.3.2 Focus group interviews

The researcher conducted focus group interviews to collect data from the learners in the Intermediate Phase. As indicated in Chapter 3, six leaners were sampled from School A representing the Grade 4 and Grade 5s and the other three learners were sampled from School B representing the Grade 6s. The learners were called Participants 1 to 9.

a) Learners' experience with robotics

Learners showed a vast experience in robotics and highlighted that they had been participating in many competitions. According to Participant 1: *"I have been taking part in many robotics competitions on a cluster level whereby we used to compete with our neighbouring schools".* The lessons offered by educators contributed positively on learners' experience with robotics and encouraged them to fully participate. According to Participant 4: *"I was participating in WRO which gave me a lot of confidence even though we did not win the competition".*

Learners enjoy working with their peers to compete in robotics since it gives them exposure to solve problems collectively and share ideas. Participant 4 stated: *"I enjoy working with my peers and it feels good to work as a team"*. Learners indicated that they had started robotics at the beginner level and initially it was something complicated until they had hands-on experience. Moreover, Participant 5 asserted: *“I have never thought I would be able to assemble and program the robot on my own”.*

b) Ease of use and usefulness learners find when learning with robotics

Some learners find robotics easy to use since they make use of manuals and videos to guide them, and others believe that robotics could be tricky sometimes especially when you have to put more sensors in one robot. Participant 2 highlighted*: “I am very confident and find it easy to use robots”.* Learners’ experiences with technology contributes positively to their effective use of robotics for learning. Participant 3 asserted: *“I have always been surrounded by technological gadgets and I enjoy navigating applications”.*

Learners believe that their teachers and coaches also make things easier for them to use robotics since they guide them step by step until they master the skills. However, once learners have mastered the skills, they are able to work on their own and gain confidence. *According to Participant 4: “I am able to program and practice on my own when preparing for competitions”.* Learners’ willingness to learn and their passion with the integration of technology builds their confidence in robotics.

Learners find robotics an effective and creative educational tool that makes learning fun and easy. According to Participant 2: “*Robotics is fun and interesting as we learn through playing and discussing with our peers*”. The activities and missions provided when learning with robotics provide learners with experiential and meaningful learning since it is based on hands-on learning and grants them opportunities to develop an interest in STEM related careers such as programmers and engineers. According to Participant 4: “*Some of the robotics activities feels so real and more practical which encourages us to like technology and science*”. Moreover, robotics increases learners’ interests and understanding of math concepts practically, since some of the activities mainly revolve around math. Participant 5 highlighted that: *“learning with robotics makes math more practical as we count the number of rotations and create turns through programming which involves angles”.*

The recognition of robotics as a key element in enhancing educational experiences, particularly in the development of problem-solving skills and teamwork, is becoming increasingly prominent. Highlighted by an educator in named Karen, "Robotics allows learners to engage in solving real-life problems which enables them to work in teams to systematically solve problems..." (Karen), this statement is congruent with the research of Afari & Khine (2017), who underscore the importance of robotics in cultivating systematic problem-solving skills in learners. Furthermore, Anwar, Bascou, Menekse & Kardgar (2019) reinforces the relevance of robotics in equipping students with skills necessary for the fourth industrial revolution, signifying its pertinence in contemporary education. Jawaid, Javed, Jaffery, Akram, Safder & Hassan (2020) study also supports the transformation of teaching and learning processes through robotics integration, making them more dynamic and engaging. These findings collectively emphasise the capability of robotics not only in developing technical skills but also in fostering vital life skills such as teamwork and systematic thinking, thus preparing learners for future challenges and opportunities.

c) Challenges while learning with robotics

Learners have highlighted some challenges that they experience when learning with robotics. The challenges experienced by learners are mainly related to external challenges. Some of these challenges are interrelated with the ones that were highlighted by their teachers when integrating robotics for teaching and learning. The challenges experienced by learners are as follows: fewer allocated technological resources, time allocated for robotics lessons, internet connections and malfunctioning of technological gadgets for robotics.

Fewer allocation of technological resources was highlighted as one of the challenges experienced by learners, which forces them to share with their peers and consumes a lot of time. According to Participant 3: *“When we are sharing the technological resources, it becomes difficult to finish activities on time”*. Participant 2 further highlighted that *“when we share technological resources, we do not have enough time to fully work on our activities since we have to handover to others”.* Moreover, time allocated for learning with robotics is one of the challenges learners encounter when learning with robotics. According to Participant 1: *“We hardly finish our robotics programs due to limited time provided per session”.*

The issue of internet connection sometimes hinders the smooth learning with robotics. Participant 5 stated that*: "Sometimes we have connectivity issues and we have to use other platforms to navigate networks".* Moreover, the hardware malfunctions also negatively influence the learning process with robotics. According to Participant 6: "*Some of the devices just jam or get damaged and it takes time for them to be repaired".* Learners' challenges while learning with robotics are beyond their control.

d) Attitudes towards the use of robotics for learning

Learners' attitudes towards the use of robotics are positive and they are excited about it and perceive robotics as an educational tool to enhance and promote 21^{st} century skills. According to Participant 5: *"Robotics is very interactive and builds my confidence in math, science and technology"*. Moreover, some participants perceive robotics as a great approach to learn since it is based on hands-on learning, and they get an opportunity to construct their own designs. Hence, this improves their creativity and innovation skills.

Robotics competitions stimulates learners' confidence and attitudes toward the use of robotics for learning. According to Participant 4: "*Robotics competitions are very special and entertaining since we get an opportunity to meet with learners from different schools and the winning schools are given a chance to progress and represent South Africa abroad*". The support and guidance learners are provided with by their teachers and parents allows them to be positive and they perceive robotics as one of the educational tools that can open opportunities for them. According to Participant 2: *Our parents support us throughout the learning process with robotics and sometimes accompany us when attending competitions".* Moreover, Participant 1 highlighted that "*our teachers support us by encouraging us about the importance of robotics in education and opportunities it creates*".

4.3.3 Field notes

The researcher has managed to collect data through field notes, which encompass the facial expressions and gestures of the participants during the semi-structured and focus group interviews. Teachers expressed their optimistic ideas with confidence when asked about technological training and impact on their teaching. When teachers were asked about their experience in using robotics in the Intermediate Phase, some took time to respond to the question while putting a hand on their head. It showed that they needed time to think thoroughly as compared to when they were asked about their technological training and impact on their teaching. Kathy was a bit nervous and confused when discussing her experience with robotics. Marklye was very confident and explained in detail about his experience with robotics in the Intermediate Phase.

The ease of use of robotics question raised frustrations and dropped the confidence and participation of most of the participants. When teachers were asked about the ease of use of robotics, they seemed like they really needed some help and expressed the issues that affect them when administering lessons with robotics. As a result, most of the teachers expressed that robotics is not easy and provided their reasons to back up their opinions. When teachers were asked about the importance of integrating robotics in the Intermediate Phase for teaching and learning, they were very confident and active in responding to the question and provided the advantages of having robotics. Overall, teachers value the integration of robotics into teaching and learning regardless of the challenges they experience when administering robotics lessons.

Learners were asked six questions through the focus group interviews. The first question, learners were asked was about their favourite subjects and they were very active and excited when responding to the question. The learners' facial expressions were very positive throughout the interviews even though some were just giving one-word answers. However, some were a bit shy to contribute or answer the questions while the interview progressed. Some learners were using gestures such as head and hand movements when responding to the questions to show that they were thinking or agreeing with their peers on certain ideas. Overall, the participants were very kind, enthusiastic and patient during the interviews. The interviews went smoothly, there were no negative attitudes, gestures or language to show disrespect or anger.

4.3.4 Observations

The researcher managed to observe some of the lessons as part of the data collection strategy. Mokoena's lesson was observed, all learners had their technological devices, and access to the internet was very strong. The lesson was very interactive, and learners were participating on their own, Mokoena only introduced a lesson by showing a video clip through an overhead projector and explained the activity for the day. The learners then went to their respective groups and started working on their own. The learners' facial expressions were very positive and Mokoena was confident when conducting the lesson as well. The pictures below depict what transpired in Mr. Mokoena's class.

Photograph 1: Mr Mokoena's students' execution of robot activities

Photograph 2*:* Learners' robotics workstation

In Kathy's class, the learners were working individually and each one had a tablet and the robot. The lesson started with the teacher showing learners how to attach the colour sensor and to program the robot to follow specified colours on the mat. The teacher showed positivity and a high quality of content knowledge and even delivered a practical example after programming her own robot. The learners were able to follow the instructions and some managed to finish the activity as instructed. However, others were complaining about their robots not being able to upload the program they had programmed. As a result, the teacher replaced the robots, and all learners were assisted.

In Marklye’s lesson observation, the lesson was based on the preparation for the upcoming WRO competition. Therefore, learners had their own mat and worked in groups to compete with their classmates. The winning team was nominated as the one that would represent the school for the upcoming competition. However, during their internal competition learners and Marklye had the issue of internet connection and found it difficult to download the online videos as their tutorials. The issue was partially sorted out later whereby Marklye connected learners to the internet with his personal phone.

The researcher was fortunate to be invited by one of the schools as a guest to the WRO competition. The WRO competition consisted of many schools from the different provinces and learners were participating as groups. Each team consisted of four learners and their coach/teacher. Learners and coaches were very excited about this competition. When learners arrived at the competition, they were given workstations and their coaches stood on the other side. There are judges and timekeepers and coaches are not allowed to intervene.

Photograph 3: WRO competition

4.4 Findings

The study investigated the teachers’ and leaners’ acceptance of the use of robotics in the Intermediate Phase. As a result, this section of the study tends to summarise the answers to the primary research question: **What influences teachers’ and learners’ acceptance towards the use of robotics?** The main research question was divided into four research sub-questions, which are as follows:

1. What are internal and external factors that influence the use of robotics in primary school education?

2. What are the attitudes of teachers and learners towards the use of robotics?
3. How easy do Intermediate Phase teachers and learners find it to use robotics?
4. How useful do Intermediate Phase teachers and learners find robotics in their teaching and learning?

4.4.1 Internal and external factors that influence the use of robotics in primary school education

The findings of this study show that there are various internal and external factors, which influence the use of robotics in primary school education. The lack of technological resources, continuous training for educators, time allocation for lessons, cost and affordability of robotics resources are major challenges, which influence the implementation, teaching and learning with robotics in primary school education. Moreover, lack of support from colleagues, SMT and SGB and unscheduled power cuts during robotics lessons are also regarded as major challenges, which influence the implementation of robotics. A study by Writer (2021) shows that lack of adequate technological resources and accessibility to internet are the main challenges which schools experience when integrating technology for teaching and learning.

Technological skills and training for teachers is a major key element for the successful integration and implementation of robotics into teaching and learning (Chambers & Carbonaro, 2018). This statement is supported by Piatti (2020) who indicated that teaching and learning with robotics requires an ongoing and consistent practise in order to master the essential skills. Moreover, Curto and Moreno (2016) particularise on this notion by highlighting that teachers should get adequate support for integrating recently introduced technologies.

The study also revealed that time allocation for robotics lessons is one of the hindrances for adequate teaching and learning with robotics. The lessons could not be completed during the time allocated due to technical glitches, internet connectivity and lack of adequate resources. A study by Chisango and Marongwe (2018) shows that time is one of the constraints for successful implementation of technology in education and poses a huge obstacle. According to Writer (2021), time is necessary for teacher professional development and co-curricular activities. However, a study by Foss and Rasmus (2019) shows that exploration and learning with robotics requires ample time as compared to traditional teaching preparation because learners work in groups; technical setup and troubleshooting are required and ensuring that all learners are connected to the internet before the lesson commences. Moreover, robotics is based on a trial-and-error learning approach.

Lastly, the research revealed that the cost of robotics resources and lack of support from colleagues, SMT and SGB influences the integration of robotics in primary schools. The technological resources for robotics seems to be more expensive and schools do not have enough budget to include them on their LTSM procurement. As a result, most schools rely on sponsors and donations from different service providers for robotics resources. Akilbekovna (2021) supports the statement that technological developments are increasing rapidly within the education sector, and this may put more pressure on a school's budget and affordability to keep up with the latest technology.

The lack of support from SMTs also affects the integration of robotics in schools as teachers often feel helpless, rely on the internet for support and outsource information on their own. A study by Amutha (2020) shows that the SMT plays a vital role in ensuring that the technology is fully integrated for teaching and learning at schools by supporting, guiding and providing training for teachers. However, according to Foss and Rasmus (2019) without proper guidance and support from the SMT the integration of robotics in schools will not be productive and meaningful to learning. Moreover, the lack of support from the SGB denies learners and teachers opportunities to enhance teaching and learning with robotics. A study by Akilbekovna (2021) shows that the SGB should promote and ensure effective teaching and learning by providing adequate resources for quality education.

4.4.2 Attitudes of teachers and learners towards the use of robotics

A study by Ahmed and Kazmi (2020) found that teachers' attitudes towards the acceptance and use of technology could be regarded as one of the obstacles for future use and integration of technology in schools. Farjon et al. (2019) who supports this notion asserted that the integration of technology in the learning environment is strongly affected by the attitudes of teachers. Moreover, teachers' attitudes towards the use of technology are mainly grounded from their current and previous use of technology. Hence, positive attitudes of teachers determine the future use of technology in the learning environment.

The study discovered that teachers' and learners' attitudes towards the use of robotics are positive and inspirational. Teachers' technological experience and skills have significant impact on the integration of robotics for teaching and learning which also influences their attitudes towards the utilization of technology. A study by Jaipal-Jamani and Angeli (2017) shows that early integration of robotics in primary schools will boost learners' confidence in the use of technology and allow educators to keep up with 21st century skills and technological developments. Moreover, according to Chambers and Carbonaro (2018) teachers' willingness and their depth in pedagogical content knowledge in robotics influences learners' attitudes towards the use of robotics. Learners enjoy experiential learning and feel comfortable when learning with technology. The integration of robotics into education adds value to learning by enriching learners' interest in the lesson (Lanka, 2021)

4.4.3 Robotics ease of use in the Intermediate Phase

Teachers have different experiences when integrating technologies for teaching and learning which are related to perceived ease of use, effectiveness and challenges they experience when integrating technology (Eguchi, 2016). This notion is supported by Akilbekovna (2021) who asserted that the utilisation of technology in classrooms has its own challenges and achievements, which are based on the schools' context. In this study, the teachers have a variety of experiences in terms of the ease of use of robotics in the Intermediate Phase.

The lack of consistent and continuous robotics training for teachers has a huge impact on the perceived ease of use, skills and knowledge when integrating robotics into their lessons. As a result, some of the teachers find it difficult when conducting lessons with robotics. Moreover, a study by Lanka (2021) highlighted that teachers' lack of technological training and skills development workshops is the obstacle for integration and facilitation of technology in the learning environment, which in turn affects the ease of use.

Two teacher participants find robotics easy to integrate into their lessons and enjoy working with technology. The participants are innovative, creative and outsource information from different sources such as watching online videos, colleagues and workshops to gain more content knowledge in robotics. Teachers who uplift their technological skills through professional development workshops have better understanding of technology and integrate it more often into their lessons (You et al., 2021). Moreover, according to Ahmed and Kazmi (2020) teacher professional developmental workshops on technology have a positive influence on teachers' perceived ease of use of technology.

4.4.4 The usefulness of robotics in the Intermediate Phase for teachers and learners

To explore what contributes to teachers' and learners' acceptance towards the utilization of robotics in the Intermediate Phase, teachers' and learners' perceptions on how useful and vital robotics is, should be discovered. The study believed that regardless of challenges that teachers and learners experience during teaching and learning with robotics, the participants perceive robotics as a fundamental technological learning tool. The integration of robotics builds learners' confidence and enhances essential 21st century skills (Nouri et al., 2020).

The study also revealed that robotics incorporates practical strands from different subjects such as Mathematics, Technology, Science and Engineering, which helps learners to develop content knowledge. Robotics creates opportunities for learners to develop a foundation of engineering and programming at an early age. This view is supported by Akilbekovna (2021) who asserted that the integration of robotics in teaching and learning will provide learners with stimulating and very engaging environments of science, technology and engineering and allow them to directly experience the practical applications of theoretical concepts in the STEM spectrum.

4.5 Overall significance of robotics in education

The significance of robotics in developing essential skills in learners is being increasingly recognized in the field of educational research. As a teacher in named Kathy noted, "*Robotics encourages creativity and enhances collaboration skills such as investigation,* *making evaluations, and it boosts learners' confidence in digital skills*." (Kathy) This aligns with the findings of Jagust, Cvetkovic-Lay, Krzic & Sersic (2018), who stress the importance of robotics in fostering creativity and problem-solving capabilities in students. Additionally, Stewart, Baek, Kwid & Taylor (2021) support the assertion that robotics education significantly enhances collaboration skills, preparing students for a future in which teamwork and digital literacy are essential. The role of robotics in increasing digital confidence is further affirmed by Anwar, Bascou, Menekse & Kardgar (2019), who advocate that early exposure to robotics and coding strengthens learners' abilities to navigate digital environments. Therefore, the application of robotics in educational settings not only supports academic learning but also cultivates critical life skills, positioning learners for success in an increasingly technology-driven world.

The recognition of robotics as transformative in the realm of education, particularly in elevating cognitive development and enhancing teaching standards, is becoming more pronounced. An educator named Tom articulated, "*Robotics uplift the standard of teaching and learning in the Intermediate Phase...it is indeed a great approach to move from the traditional way of teaching and to meet the current needs of the learners...*" This observation aligns with Zhang & Zhu (2022) research, which elucidates the pivotal role of robotics in cultivating higher-order thinking skills during the Intermediate Phase. Additionally, Jawaid et al. (2020) underscore the imperative of robotics in addressing the demands of the Fourth Industrial Revolution within educational frameworks, advocating for innovative teaching methodologies in modern education. A study by Anwar et al. (2019) further affirm the impact of robotics in transitioning from traditional teaching methods, thus fostering an environment conducive to the development of essential 21st-century skills. Consequently, the application of robotics in education, as demonstrated in the interview, exemplifies a strategic and progressive approach to adapting educational practices to the evolving requirements of contemporary learners.

The efficacy of robotics in fostering engaging, hands-on learning environments is increasingly recognized in the field of educational research. Sarah stated, "*Robotics provides an interactive and hands-on learning environment that captures learners' attention and keeps them engaged...*" This is consistent with Roberts and Alam (2022) findings, which emphasise the significance of robotics in sustaining student engagement and augmenting problem-solving abilities. Alam (2022) research further highlights the role of robotics in developing critical thinking skills, essential for navigating the complexities of today's world. The capacity of robotics to connect classroom learning with real-world scenarios is corroborated by Jawaid et al. (2020) study, illustrating how robotics equips students for future challenges by enhancing their technological literacy. Thus, the integration of robotics in educational settings, as described in the interview, transcends being a mere technological update, serving as an indispensable pedagogical instrument for endowing learners with pertinent skills and knowledge.

The pertinence of robotics in preparing students for a technologically sophisticated future is a recurrent topic in educational discussions. Kim remarked, "*Yes, robotics is useful for learners in the Intermediate Phase because it prepares them for the future generation...*" This aligns with Anwar et al. (2019) findings, highlighting the escalating significance of programming and technological competencies in education. Additionally, Jawaid et al's (2020) work advocates for the necessity of robotics education in arming learners with the capabilities required to navigate the rapidly changing technological terrain. Therefore, the inclusion of robotics in educational curricula, as indicated in the interview, not only meets present educational demands but also strategically prepares students for impending challenges and opportunities in a technology-centric global landscape.

Participants demonstrated favourable dispositions towards robotics, expressing enthusiasm and perceiving it as a valuable educational instrument for fostering 21st-century skills. For example, James articulated, "*Robotics is very interactive and builds my confidence in Math, Science, and Technology*." Furthermore, certain participants regarded robotics as an effective learning methodology due to its hands-on nature, which facilitates the construction of personal designs, thereby enhancing creativity and innovation skills. The role of robotics competitions in bolstering learners' confidence and attitudes towards the utilisation of robotics in education was also highlighted. Karen noted, "*Robotics competitions are very special and entertaining since we get an opportunity to meet with learners from different schools and the winning schools are given a chance to progress and represent South Africa abroad*." Additionally, the encouragement and guidance provided by educators and parents play a significant role in shaping learners' perceptions of robotics as an indispensable tool in education.

4.5 Conclusion

This chapter outlined the data collected through the semi-structured interviews, field notes, focus groups and observations. The data was analysed and interpreted through data steps by Cresswell (2017). Teachers and learners expressed their feelings and perceptions about the integration of robotics in the Intermediate Phase. Robotics is regarded as an essential educational tool and experiential learning which promotes STEM related subjects. The integration of robotics in the Intermediate Phase creates meaningful and valuable education for teachers and learners. The findings of this study were interpreted and analysed with arguments supported by the literature reviews and the theoretical framework that underpins the research.

CHAPTER 5: Recommendations and conclusions

5.1 Introduction

In Chapter 4, the researcher analysed the data and provided outcomes in line with the rationale of the study. The rationale of this study was to explore the factors that influence teachers' and learners' acceptance of the use of robotics in the Intermediate Phase. In this final chapter, the researcher will present the summary of the research, the limitations, contributions and recommendations of this study.

5.2 Summary of the research

The DBE objectives are to enhance the quality and optimal level of education in the South African education system (DBE, 2021a). In responding to the 4IR, the DBE have introduced robotics in education to keep up with the educational trends of other countries and to ensure that learners and teachers are well equipped for the 4IR (Ferrein & Meyer, 2019). In addition, the introduction of robotics in the education system promotes the STEM related subjects by inculcating how Science, Technology, Engineering and Mathematics work together through hands-on learning (Lanka, 2021). The purpose of this study was to explore the factors that influence teachers' and learners' acceptance of the use of robotics in the Intermediate phase. The literature review chapter of this study outlined and deliberated on the history of robotics, the state of the robotics curriculum in the South African education system and robotics as an educational learning tool in the world. Moreover, teachers' acceptance towards the use of robotics and factors that influence the use of robotics were discussed. The literature also revealed the integration of robotics in public and private schools in South Africa. A detailed elucidation was provided on how the Technology Acceptance Model was integrated as the theoretical framework that underpins the study.

In Chapter 3, a qualitative research approach was integrated to collect data by incorporating a case study as the research design. The ontological and epistemological perspectives of this study were discussed involving socio-constructivism and interpretivism. Two schools were identified for collecting data and the researcher purposively sampled nine learners and nine teachers. The researcher further explained why purposive and convenience sampling were integrated as sampling approaches for this study.

The semi-structure interviews, field notes, focus group interviews and observations were incorporated as data collection strategies for this study. All the strategies were motivated for their worth and purpose in this study. The methodological norms involving credibility, dependability, transferability and confirmability were fully discussed together with how they would be ensured. Moreover, research ethics were taken into consideration in line with the University of Pretoria's ethical considerations.

In Chapter 4, the data was analysed by using data analysis steps by Creswell (2017). Demographics of teacher participants were provided focusing on age, number of years teaching, subject specialisation and gender. Demographics of learners were also provided focusing on age, grade and gender. The researcher further used pseudonyms to protect the identities of the participants. The data was analysed in all data collection strategies used as per the criteria. The researcher drew up the findings from the analysed data by dividing the main research question into four sub-questions.

The study explored the internal and external factors that influence the use of robotics in primary school education. There are various factors, which teachers and learners experience when teaching and learning with robotics. The attitudes of teachers and learners in the Intermediate Phase also play a significant part in the application and the use of robotics. Lastly, how useful and easy Intermediate Phase teachers and learners find using robotics has a huge impact on their attitudes, acceptance and future use of robotics.

5.3 Limitations of the study

This study has the following limitations:

Firstly, the study only involved two private primary schools in Pretoria, Gauteng, which administers robotics as part of their curriculum, and it was a qualitative study involving nine learners and nine educators. This means that the outcomes of this research cannot be generalised or applied to all primary schools or a larger population.

Only teachers who are experienced and trained to teach robotics were sampled for this study. Hence, the perspectives or opinions of other educators who are not teaching robotics were not considered.

Only two stakeholders were sampled for this study, which are teachers and learners. The inclusion of the SGB and school principal in the study might have highlighted different views especially on the issue of LTSM procurement and budget.

In focus group interviews, some learners were just agreeing with their peers without really giving their own perspectives.

The research, while offering significant insights into the integration of robotics within educational frameworks, possesses certain limitations. The scope of the sample, predominantly consisting of participants from a particular geographic and socio-economic background, presents challenges to the generalisability of the study's findings across diverse educational contexts, particularly in regions with varying levels of technological and infrastructural advancement. This factor is especially pertinent in light of the diverse educational settings within South Africa, which range from well-equipped urban institutions to less resourced rural schools (Michalec et al., 2021). Additionally, the research methodology, predominantly reliant on qualitative interviews, offers depth in individual perspectives but does not provide the comprehensive statistical analysis typically associated with quantitative methods. This could potentially restrict the study's capacity to discern wider patterns and trends in the adoption and efficacy of robotics in educational settings (Michalec et al., 2021). The investigation also does not extensively address the long-term ramifications of robotics integration in education, such as its enduring effects on students' academic achievements and skill development, which are critical for a thorough understanding of the advantages and challenges associated with the implementation of robotics in educational systems (Anwar et al., 2019). These limitations highlight the necessity for future research endeavours that are more expansive, encompassing diverse participant demographics, and methodologically varied to gain a comprehensive understanding of the ramifications of incorporating robotics into educational curricula.

5.4 Contribution of the study

As highlighted in Chapter 1, robotics is the current digital technology in education and most scholars focus specifically on the value and impact of robotics in education without considering the attitudes and acceptance of teachers and learners. This study aimed to bridge the gap by not only discussing the importance and the impact of robotics in education, but also explored teachers' and learners' acceptance and their attitudes towards the use of robotics. Moreover, as part of the Department of Basic Education's mandate of piloting the robotics curriculum in all public schools from Grade R-7, the findings of this study are relevant for the integration and implementation of the robotics curriculum.

5.5 Theoretical conclusions

The primary data derived from the interviews in the study substantiates the principle of perceived usefulness as delineated in the Technology Acceptance Model (TAM). Respondents, encompassing both educators and learners, exhibited favourable perspectives towards robotics, recognising its value as a tool for augmenting educational outcomes. This observation is congruent with the TAM's concept of perceived usefulness, where technology is posited to enhance job performance (Davis, 1989). Educators, for instance, identified robotics as pivotal in cultivating 21st-century skills among learners (Michalec, O'Donovan & Sobhani, 2021), while learners acknowledged the interactivity and confidence-enhancing properties of robotics in subjects such as Mathematics and Science (Anwar et al., 2019). Such perceptions underscore the TAM's assertion that the perceived usefulness of technology is a key driver of its acceptance.

Regarding the perceived ease of use aspect in TAM, which relates to the extent to which individuals believe that using a technology would be effortless (Davis, 1989), the primary data presented mixed reactions. Some respondents found robotics engaging and user-friendly, indicative of ease of use, while others, especially teachers, voiced concerns regarding the complexities involved in incorporating robotics into the curriculum (Michalec et al., 2021). This dichotomy suggests that although robotics is generally seen as accessible by learners, its integration within educational frameworks presents challenges for teachers, thereby partially validating the TAM's concept of perceived ease of use.

In the context of TAM, attitudes towards using technology are shaped by its perceived usefulness and ease of use, factors that influence actual system usage (Taylor & Todd, 1995). The study's primary data demonstrates a generally positive attitude towards employing robotics in education. This is manifested in learners' enthusiasm for robotics competitions and experiential learning activities Anwar et al. (2019), indicated that favourable perceptions of both usefulness and ease of use cultivate a positive attitude towards technology adoption.

The final element of TAM encompasses the behavioural intention to use technology, influenced by attitudes towards its usage. The primary data reveals a robust inclination among both learners and teachers to engage with robotics, motivated by the recognition of its tangible benefits in skill development and educational enhancement (Jawaid et al., 2020). However, among educators, this intention is tempered by the challenges encountered in implementation, suggesting that while there is an eagerness to embrace robotics, practical obstacles must be addressed to fully actualise this intention.

5.6 Addressed research gaps

Gap 1: Impact of robotics on 21st century skills development in learners

A notable research gap addressed by the study concerns the influence of robotics on the development of 21st century skills among learners in the Intermediate Phase. Although previous research has delved into the potential of robotics in education (Michalec et al., 2021), there exists a requirement for more detailed empirical data, especially regarding the impact of robotics on skills such as creativity, critical thinking, and problem-solving within the South African context. Data collected from interviews with educators and learners offer insightful contributions in this domain. The study reveals that interaction with robotics significantly bolsters learners' confidence and interest in STEM subjects (Anwar et al., 2019), which is vital in regions where STEM education is increasingly emphasised. Additionally, the research offers an understanding of the effective integration of robotics to foster these skills, addressing a previously identified gap related to the practical application of technology-enhanced learning (Michalec et al., 2021).

Gap 2: Teachers' readiness and attitudes towards robotics integration

Another research gap addressed by the study pertains to the readiness and attitudes of teachers towards integrating robotics into the educational curriculum. Existing literature highlights the significance of teacher training and attitudes towards the implementation of new technologies in educational settings (Hew et al., 2019). This study enriches this discourse by providing empirical data reflective of the South African educational landscape. The primary data unveils a mix of enthusiasm and reservations among teachers concerning the adoption of robotics, suggesting a complex interaction between perceived usefulness, ease of use, and the necessity for professional development. These findings are in alignment with Alam (2022)'s emphasis on the criticality of teacher training for the successful assimilation of educational technologies. The study, therefore, fills an essential gap in comprehending the determinants of teachers' acceptance and effective utilisation of robotics in their pedagogical approaches.

Gap 3: Practical challenges in the implementation of robotics in education

The third research gap addressed by the study focuses on the practical challenges encountered in implementing robotics within the education system. Prior studies have recognised various barriers to the integration of technology in educational contexts, including resource limitations and curriculum constraints (Anwar et al., 2019). The present study expands on these findings by exploring specific challenges prevalent in South African educational institutions, such as resource availability, infrastructural requirements, and the congruence of robotics within the existent curriculum. This exploration is particularly pertinent given the socio-economic diversity of South African schools, where disparities in resources can markedly affect the efficacy of technology integration (Tsagkaraki et al., 2021). Consequently, the study provides valuable perspectives on the practical aspects of implementing robotics in diverse educational settings, thereby offering crucial insights for policymakers and educators in similar contexts.

5.7 Recommendations

The following recommendations have been made based on the findings of this research.

Recommendation 1: Enhancement of teacher training and professional development in robotics and educational technology

A paramount recommendation from the study is the enhancement of teacher training and professional development specifically in the realms of robotics and educational technology. Training should have the objectives and assessments whereby educators are assessed theoretically and practically after being trained. The training should also accommodate educators according to their level of competency with robotics. There should be trained personnel amongst the staff members in schools who deal timeously with technical issues to assist with any technical glitches. The trained personnel could also train other staff members.

Data indicate a disparity between teachers' enthusiasm for integrating robotics and their level of preparedness and comfort with these technologies (Michalec et al., 2021). Educational institutions and policy makers are thus advised to invest in comprehensive training programs that furnish teachers with the requisite skills and confidence for the effective incorporation of robotics into their teaching methodologies. Such programs should encompass not only technical training, but also pedagogical guidance, facilitating the seamless integration of robotics with established teaching methods. Furthermore, continual professional development opportunities are essential to keep educators updated with the latest advancements in educational technology (Hew et al., 2019).

Recommendation 2: Planning and preparation

Planning in robotics lessons is absolutely crucial. Teachers should have weekly and daily plans for their robotics lessons and accommodate all learners. Teachers should prepare their robotics lessons and put all teaching and learning materials in place. All systems should be tested before the actual lesson begins to avoid technical glitches during the lesson, which will affect time constraints.

Recommendation 3: Integration of robotics into curricula and pedagogical adaptation

A further recommendation entails the meticulous integration of robotics within existing curricula and the adaptation of pedagogical strategies to accommodate this emergent technology. This process involves aligning robotics with educational standards and learning outcomes, thereby ensuring its application is fundamental to the learning process rather than supplementary. Curricula should be structured in such a way that robotics enhances understanding in disciplines like Mathematics and Science and fosters the development of critical thinking and problem-solving skills (Anwar et al., 2019). Additionally, instructional strategies ought to evolve to include more hands-on, project-based learning approaches, which have been proven effective in engaging students and enriching their learning experiences through robotics (Michalec et al., 2021).

Recommendation 4: Addressing resource allocation and infrastructure issues in robotics implementation

Addressing the challenges of resource allocation and infrastructure is crucial for the successful implementation of robotics in educational environments. The study underscores the disparities in resources among schools, particularly those underfunded or in rural areas. To counteract these disparities, it is recommended that governments and educational authorities devise strategies for equitable resource distribution. This strategy should encompass the provision of financial resources for the acquisition of robotics kits and the enhancement of technological infrastructure within schools. There should be a commitment to ensure ongoing maintenance and support for these technologies, a critical factor for their sustained application in educational settings (Anwar et al., 2019).

The SGB, SMT and ICT committee alongside the school principal should have a budget to purchase robotics resources and ensure that the ICT committee is functional and proactive. They should also come up with fundraising activities or ask for sponsors and donations if the school has limited funds. The issue of power cuts could also be eliminated by installing solar panels to supply the whole school with electricity. Learners should be supported with all the learning support materials they need during the robotics lessons to ensure that they all take part and are included in the lesson.

Recommendation 5: Promotion of collaborative learning and student engagement using robotics

This recommendation advocates for the utilisation of robotics as a tool to promote collaborative learning and augment student engagement. Primary data suggests that robotics fosters an environment conducive to collaboration, where students engage in teamwork, idea sharing, and problem-solving tasks. To optimise these benefits, educational initiatives involving robotics should be designed to encourage teamwork, communication, and peer-to-peer learning. The incorporation of elements such as robotics competitions and collaborative projects can further stimulate student motivation and engagement, providing a dynamic and competitive platform for the application of learning (Alam, 2022).

Recommendation 6: Development of context-specific robotics programs

The development of robotics programs that are specifically tailored to suit the distinct educational and socio-cultural contexts of various regions is recommended. Such an approach aims to address the disparate levels of access and exposure to technology prevalent in schools across diverse regions, with particular reference to countries like South Africa (Gunal, 2019). Programs of robotics that are customised to align with the local conditions, resource availability, and educational requisites could significantly augment the relevance and efficacy of integrating technology within educational frameworks. The goal is to move away from a universal application of robotics education, instead adopting a model that is flexible and responsive to the unique needs and circumstances of each educational environment.

Recommendation 7: Strengthening public-private partnerships in robotics education

The fortification of collaborations between public entities and private sector organisations in the realm of robotics education is also advised. Such cooperative efforts between educational institutions, governmental bodies, and industry entities could form a solid foundation for the rollout of robotics programs (Jawaid et al., 2020). These alliances have the potential to facilitate the sharing of resources, expertise, and funding, thereby addressing financial and infrastructural challenges that may confront schools. Engagements with industry partners can additionally provide practical insights into the application of robotics, thereby enhancing the pragmatic aspect of robotics education.

Recommendation 8: Continuous assessment and evaluation of robotics programs

It is imperative to implement ongoing assessment and evaluation of robotics programs. This process should involve consistent monitoring and analytical review of the outcomes associated with robotics education, ensuring alignment with the objectives of augmenting student learning and skill acquisition (Tzagkaraki et al., 2021). It is essential to establish mechanisms for evaluation that assess the impact of robotics on student learning, teacher effectiveness, and the overall quality of education, both in the short and long term. Utilising feedback from these evaluations can inform necessary modifications and improvements to the robotics programs.

Recommendation 9: Fostering a culture of innovation and experimentation in schools

Finally, it is advocated to cultivate a culture within educational institutions that promotes innovation and experimentation, particularly in the context of robotics education. Such a cultural shift would encourage educators and students to experiment with novel ideas and methodologies in the teaching and learning processes involving robotics (Stewart et al., 2021). Educational settings should provide an environment where taking risks is supported, and perceived failures are considered valuable learning opportunities. This innovative ethos could inspire creative applications of robotics in education, potentially leading to more stimulating and impactful educational experiences for students.

5.8 Recommendations for further study

- Further research is recommended to measure whether learners' academic performance shows some improvement in STEM related subjects after being introduced to the robotics curriculum.
- Research on the relationship between the robotics and subject matter in STEM related subjects is needed.

- Research on the influence of robotics on teacher professional development and pedagogical shift will be interesting.
- Comparing the integration of robotics curriculum in private and public schools across South Africa will be beneficial.

5.9 Conclusion

Technology is increasing rapidly, and new inventions are explored daily. This puts pressure on the education system to adapt to newly introduced technologies and to meet the standards set. Robotics is the current influential technological learning tool across the world used by different institutions because of its possibilities and influence on education. The findings of this study discovered that teachers and learners have positive attitudes towards the use of robotics in the Intermediate Phase and accept robotics as a new learning approach to enhance STEM related subjects. However, in order to integrate robotics to its optimal level, the school should have proper systems in place such as a supportive SGB, SMT and functional ICT committee. In addition, teachers should have adequate and continuous training and LTSM should be sufficient.

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Appendices

Appendix A: Research Approval Letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	28 February 2022
Validity of Research Approval:	08 February 2022– 30 September 2022 2022/73
Name of Researcher:	Mapheto D
Address of Researcher:	158 Orchards Village
	The Orchards Pretoria North
	Doreen Street
Telephone Number:	072 063 1390
Email address:	U12089843@tuks.co.za
Research Topic:	Teachers' and learners' acceptance towards the use of robotics in the intermediate phase
Type of qualification	Masters
Number and type of schools:	2 Primary Schools
District/s/HO	Tshwane South

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

28/02/2022

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.
3. **Because of COVID 19 pandemic researchers can ONLY collect data online, telephonically or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate. The approval letter will then indicate the type of arrangements that have been made with the school.**
4. **The Researchers are advised to make arrangements with the schools via Fax, email or telephonically with the Principal.**
5. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.
6. A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
7. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
8. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
9. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.
10. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
11. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
12. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
13. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
14. On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.
15. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
16. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

Mr Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 28/02/2022

2

Making education a societal priority

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7th Floor, 17 Simmonds Street, Johannesburg, 2001
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Appendix B: Consent letter to the school principal

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Dear Sir/Madam,

REQUEST FOR YOUR SCHOOL TO PARTICIPATE IN AN INTERVIEW RESEARCH PROJECT:

Title: Teachers' and learners' acceptance towards the use of robotics in the intermediate phase.

My name is Doctor Mapheto and I am currently enrolled for a Masters' degree at the University of Pretoria under the supervision of Dr. Maryke Mihai. The title of my approved research study is: *"Teachers' and learners' acceptance towards the use of robotics in the intermediate phase"*.

The purpose of this study is to explore the factors that influence teachers' and learners' acceptance towards the use of robotics in the intermediate phase. Part of the data collection for this study will require interviews with teachers and learners. The opinions and inputs of teachers and learners are of great value for this study.

The interview with each teacher will take approximately 50 minutes and 30 minutes with each learner outside of dedicated teaching and learning time. I have included here for your information a schedule of the interview questions. I hereby request your permission to allow teachers and learners to participate in the interviews.

All participation is voluntary. No harm or injury will come to the teachers and learners during the interview. During the interviews, Covid-19 protocols will be followed by wearing masks covering the nose and mouth and maintaining a 1.5m distance between the researcher and participant(s). Please note that the decision for teachers and learners to participate is completely voluntary and this will not affect their livelihood. None of the results obtained during the interviews will be used for assessment purposes. The teachers and learners may request to leave the interview at any time without any explanation or consequences.

As part of the data collection I will be using an audio recorder to capture the interviews for research purposes. The purpose of the audio recorder is to capture and transcribe the data accurately. All information obtained during the research study will be treated confidentially, with not even the University of Pretoria or the Department of Education having access to the raw data obtained from the interviews. My supervisor and I will have access to the data. The names of teachers, learners, principal or school will not be mentioned during any phase of the study. Furthermore, pseudonyms will be used to avoid identification of the teachers, learners and school. At the end of the study, I will provide the school with a copy of the dissertation containing both the findings of the study and recommendations.

I also would like to request your permission to use your data, confidentially and anonymously, for further research purposes, as the data sets are the intellectual property of the University of Pretoria and, where relevant, project funders. Further research may include secondary data analysis and using the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

Thanking you in anticipation.

Mr. D. Mapheto
Student Researcher
University of Pretoria
u12089843@tuks.co.za
072 063 1390

Dr. M. Mihai
Supervisor
University of Pretoria
maryke.mihai@up.ac.za
082 430 2928

LETTER of CONSENT

SCHOOL PARTICAPATION
VOLUNTARY PARTICIPATION IN THE RESEARCH PROJECT ENTITLED:

Teachers' and learners' acceptance towards the use of robotics in the intermediate phase

I, ____, (Full name) the principal of

____

Please tick the appropriate block

Give consent ☐

Do not give consent ☐

to allow my school to participate in the above-mentioned study introduced and explained to me by Mr Mapheto Doctor, currently a student enrolled for a Master's degree at the University of Pretoria.

I further declare that I understand, as explained to me by the researcher, the aim, scope, and purpose of collecting information proposed by the researcher, as well as how the researcher will attempt to ensure the confidentiality and integrity of the information he collects.

______________________________ ____________________

Full name Signature

____

Date School stamp

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix C: Assent letter

ASSENT FORM FOR PARTICIPATION IN RESEARCH

VOLUNTARY PARTICIPATION IN THE RESEARCH PROJECT ENTITLED: Teachers' and learners' acceptance towards the use of robotics in the intermediate phase

I, ________________________________ understand that my parent(s)/guardian have/has given permission for me to take part in a research project about teachers' and learners' acceptance towards the use of robotics. The research project is done by Mr. D Mapheto.

I understand what the study is about and what I will be doing when taking part in the study.

I am taking part because I want to. I have been told that I can stop at any time I want to and nothing will happen to me if I do so.

______________________________ ______________________________

Your full name Signature

____

Date

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix D: Consent letters

LETTER of CONSENT

INDIVIDUAL CONSENT

VOLUNTARY PARTICIPATION IN THE RESEARCH PROJECT ENTITLED:

Teachers' and learners' acceptance towards the use of robotics in the intermediate phase

I, ____, (Full name)

Please tick the appropriate block

Give consent ☐

Do not give consent ☐

to participate as an individual in the above-mentioned study introduced and explained to me by Mr. Mapheto Doctor, currently a student enrolled for a Master's degree at the University of Pretoria.

I further declare that I understand, as explained to me by the researcher, the aim, scope, and purpose of collecting information proposed by the researcher, as well as how the researcher will attempt to ensure the confidentiality and integrity of the information he collects.

____________________________ ____________________
Full name Signature

____
Date

Faculty of Education
Fakulteit Opvoedkunde
Lefapha la Thuto

LETTER of CONSENT

PARENT PERMISSION
VOLUNTARY PARTICIPATION IN THE RESEARCH PROJECT ENTITLED:

Teachers' and learners' acceptance towards the use of robotics in the intermediate phase

I, ____, (Full name) the parent of

____

Please tick the appropriate block

Give consent ☐

Do not give consent ☐

to allow my child to participate in the above-mentioned study introduced and explained to me by Mr. Doctor Mapheto, currently a student enrolled for a Master's degree at the University of Pretoria.

I further declare that I understand, as explained to me by the researcher, the aim, scope, and purpose of collecting information proposed by the researcher, as well as how the researcher will attempt to ensure the confidentiality and integrity of the information he collects.

____________________________ ____________________

Full name Signature

____

Date

Appendix E: Interview questions for learners

Interview questions for learners

Demographics:

- **Age:**
- **Gender**
- **Grade:**

Questions:

1. Briefly explain your experience in learning with robotics.
2. Do you find it easy to learn with robotics? Why or why not?
3. Do you find robotics useful for your future career? Why or why not?
4. What challenges do you encounter while learning with robotics? Why are they challenges for you?
5. What do you see as the benefits / opportunities of learning robotics for you?
6. What are your feelings towards the use of robotics for learning?
7. How do your parents feel about the fact that you learn with robotics?
8. How do you experience the attitudes of teachers towards teaching with robotics?
9. Do you take part in the World Robotics Olympiad? How do you feel about this competition? Describe the competition. How does it work and what components does it consist of?

Appendix F: Interview questions for teachers

Demographic information:

1. Gender
2. Age
3. How long you have been teaching?
4. Which subjects are you teaching?

Interview questions for teachers

1. Briefly discuss what technology training you had and the impact thereof in your teaching.
2. What is your experience in using robotics in the intermediate phase?
3. Do you think it is useful to integrate robotics in the intermediate phase for teaching and learning? Explain your answer.
4. Do you find it easy to use robotics in the intermediate phase? Explain why or why not.
5. Do you find robotics useful for learners in the intermediate phase? Explain why or why not.
6. What are your thoughts about the use of robotics for teaching and learning?
7. What do you think your colleagues' perceptions are towards the teaching of robotics?
8. What do you think learners' perceptions are towards robotics?
9. What are the challenges that may prevent you to integrate robotics for teaching and learning?
10. What do you see as the benefits / opportunities of robotics in the intermediate phase?
11. What support do you need in order to apply robotics in the intermediate phase? Do you receive support from the school management? Why or why not?
12. Looking at the integration of robotics into teaching, do you think there is a link between robotics and subject matter? Briefly explain your answer.