Leveraging the use of Artificial Intelligence in Teaching of looping structures in Programming languages: A case of Gauteng Province Schools.

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PROTOCOL NUMBER: 2024ECE048M

Research submitted in conformity with the requirements for the degree of Master of Education in the Division of Science and Technology, University of the Witwatersrand

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Date: 17 March 2025

Acknowledgments

I would like to extend my gratitude to the following individuals for their invaluable contributions to the development of this research report:

First and foremost, I offer my heartfelt thanks to God, for granting me the joy, strength, and capacity to navigate through this journey.

I am immensely grateful to my brilliant supervisor, Dr. Alton Dewa for his support, invaluable guidance, and patience. I am truly indebted to you Sir, Thank you.

My family played a very significant role in making it possible, thank you very much.

Dedication

I, Nkosinathi Khumalo, hereby declare that this is my own unaided work except where citations and acknowledgments indicate otherwise. This research report is submitted in partial fulfilment of the requirements of the degree of Master of Education (in the field of Educational Technology) at the University of the Witwatersrand, Johannesburg. It has not been previously submitted for any degree or examination in any other university.

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Abstract

The integration of Artificial Intelligence (AI) in education is revolutionizing the teaching and learning process, particularly in programming education. This study explores the use of specific AI tools; ChatGPT, Mind Joy, and GitHub Copilot in teaching looping structures within programming languages in Gauteng Province schools; a province that represents both advanced technological adoption and ongoing educational inequalities. As South Africa's economic and arguable the centre of educational technology, Gauteng offers a unique context to assess the integration of AI in classrooms, with its mix of well-resourced and under-resourced schools providing critical insights into broader national implementation challenges and opportunities. Gauteng remains the highest province with schools that offer Information Technology (IT) as a subject. AI tools such as ChatGPT, MindJoy, and GitHub Copilot serve different pedagogical functions: ChatGPT facilitates natural language interaction, allowing learners to ask questions and receive instant explanations in conversational form; MindJoy offers structured coding exercises and gamified learning paths tailored to different skill levels; GitHub Copilot provides intelligent code suggestions within development environments, helping learners write syntactically correct and optimized code in real time.

Given the complexity of looping structures, many learners struggle to grasp these fundamental programming concepts, leading to high failure rates and disengagement. Through a qualitative research approach, data was collected via semi-structured interviews and classroom observations with Information Technology teachers from four schools. The study examines how teachers engage with AI tools, assesses their effectiveness, and identifies challenges in using AI-driven pedagogies.

Findings reveal that while these AI tools enhance learner engagement and provide real-time feedback, their implementation in classrooms remains limited due to factors such as lack of teacher training, inadequate infrastructure, and curriculum constraints. Traditional teaching methods still dominate programming instruction, despite AI's potential to personalize learning and support conceptual understanding. Teachers who effectively incorporated AI reported improvements in learners' problem-solving skills and comprehension of looping structures.

However, concerns regarding over-reliance on AI, the accuracy of AI-generated solutions, and the digital divide were also highlighted.

The study underscores the need for structured AI integration strategies, professional development for teachers, and policy adjustments to support AI-driven learning environments. By leveraging AI effectively, schools in Gauteng and potentially across South Africa can bridge the gap between traditional and modern teaching approaches, fostering a more interactive and adaptive learning experience in programming education. These insights contribute to the growing discourse on AI adoption in education and inform future strategies for AI-enhanced teaching methodologies.

Keywords: **Artificial Intelligence, Programming, Looping Structures, AI in Teaching, Digital Learning, Educational Technology, Gauteng Province**

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Chapter 1: Study Overview and Background

1.1.Introduction

Programming skills are a cornerstone of Information Technology (IT) literacy, crucial for success in the digital age. South Africa, Gauteng province, with its focus on economic development, needs a workforce equipped with these skills. However, traditional teaching methods for programming languages may struggle to cater to individual needs and keep pace with rapid technological advancements. Artificial intelligence (AI) has emerged as a potential tool to transform education (Becker, 2017). This research explores the potential of AI in enhancing the teaching of programming languages in Gauteng province schools.

According to Becker (2017), Artificial Intelligence in education (AIEd) refers to the application of AI techniques to enhance and support teaching and learning processes. It leverages the power of computers to automate tasks, personalize learning experiences, and create intelligent learning environments. While research exists on AI in education and its applications in various areas, there's a gap in specifically exploring how AI can be used to teach fundamental programming concepts like looping structures (Becker, 2017). This study aims to contribute to this specific area by investigating the effectiveness of AI-powered platforms [1]in this context. This research can contribute to the growing knowledge of AI in education. It can offer valuable insights for educators, policymakers, and educational technology as a whole to improve access to quality computer science education, particularly in areas facing resource limitations.

[1] **AI-powered platforms** are more comprehensive learning environments that incorporate AI functionalities to enhance instruction.

1.2.Background of the Study

Information Technology (IT) is the field of study that examines the interconnected physical and non-physical technologies used for data capture, processing, management, presentation, and dissemination (DBE CAPS, 2011). It focuses on activities that involve problem-solving through logical and computational thinking. Additionally, IT encompasses both hardware and software components that facilitate the electronic transmission, access, and manipulation of data and information (DBE CAPS, 2011). One of Information Technology's aims is to use appropriate techniques and procedures to plan solutions and devise algorithms to solve problems using suitable techniques and tools. This is done through 2 main components, the practical and the theory. Though most of the content is mainly based on control structures (Iteration and selection).

Figure 1-***The table below provides the six topics and sub-topics to be covered in Information Technology in grades 10-12 and the resources required for teaching IT***

Topic Area	Sub-Topics	Weighting (content)
(Practical) Solution Development	• Algorithms and Problem-Solving • Introduction to Solution Development • Application Development • Software Engineering Principles	+/-60
Theory	• Communication Technologies • System Technologies • Internet technologies • Data and information Management • Social Implications	+/-40

(From: Department of Education: Information Technology CAPS document, 2011)

The above table emphasizes the importance and the role that the practical component plays in a subject.

South Africa's decision to incorporate Information Technology (IT) into the matriculation curriculum (Grades 10-12) equips learners with vital digital literacy skills for the modern world (Department of Basic Education, 2021). However, a significant strain arises within the programming concepts section, particularly when it comes to grasping looping structures. This complexity is a major deterrent for many learners, leading them to favour the more theoretical Computer Applications Technology (CAT) subject (Adeyemo & Onoh, 2023). This trend is further supported by consistently low national exam results in looping concepts (Department of Basic Education, 2023 National Senior Certificate Results).

These concerning statistics point towards a crucial need for innovative pedagogical approaches to enhance learning outcomes. This is due to the difficulties that learners come across when dealing with programming, particularly looping structures. Learners view the looping structure in Delphi programming as too abstract and challenging, and it is too difficult to make it concrete and doable (Jonsson, 2021). Thus, many learners already have a mindset of thinking that IT or programming is difficult. In addition, many learners do not have devices such as laptops to practice what they learnt at school (Jonsson, 2021).

Artificial Intelligence (AI) presents a powerful solution to address this challenge. AI-powered tools can personalize the learning experience by delivering targeted teaching/lesson and interactive practice specifically designed to tackle difficulties with looping structures (Jovanovic et al., 2023). Unlike traditional, one-size-fits-all methods, this adaptive learning environment caters to individual learner needs. AI tools[2] can identify areas of confusion and provide tailored explanations or suggest alternative exercises until mastery is achieved. This personalized approach fosters deeper understanding, boosts learner's confidence, and gamifies the learning process, potentially reversing the trend of subject abandonment and significantly improving overall performance in programming concepts (Jovanovic et al., 2023).

Furthermore, AI can automate the grading process, providing learners with immediate feedback and allowing teachers to focus on more complex concepts or provide individual support. The integration of AI in teaching of looping structures in the IT field does not replace the teacher (Becker, 2017). Rather, it enhances the teaching and learning process of looping structures. Moreover, the current curriculum structure presents a barrier for many learners seeking to grasp programming fundamentals. By leveraging AI-powered tutoring systems[3], Gauteng province schools can personalize the learning experience for looping structures, fostering deeper understanding, boosting learner's confidence, and ultimately improving national exam results in programming concepts (Becker, 2017).

However, AI can struggle to replicate the human touch in education. They may struggle to understand the emotional state of a student, adapt to unexpected questions or explanations, or provide the kind of social and emotional support that human teachers can offer (Chen et al, 2020). While some AI tutors use gamification elements, they might not be able to fully replicate the level of engagement and motivation that a skilled human teacher can foster through their classroom presence and teaching style (Chen et al, 2020).

The demand for programming skills across diverse industries demands effective educational approaches. Gauteng province schools face challenges in equipping its youth for a future heavily reliant on IT. Traditional classroom settings may not provide the personalized learning experiences or resources needed to optimize learning for all learners. This calls for improvement in the teaching of Delphi/programming looping structures in Gauteng province schools.

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[2] **AI tools** refer to general-purpose artificial intelligence applications (e.g., ChatGPT, GitHub Copilot) used to support teaching and learning.

[3] **AI tutoring systems** are specialized platforms designed to simulate one-on-one tutoring by providing personalized and adaptive instruction.

These distinctions help avoid ambiguity and support the analysis of how different AI technologies influence the teaching of looping structures.

1.3.Problem Statement

Understanding looping structures in programming requires grasping abstract concepts such as iteration and control flow, which many learners find challenging (Ferdowsifard et al., 2021). Traditional teaching methods often fail to provide the necessary support, as they do not effectively utilize technology to demonstrate the flow of loops in an interactive manner. In conventional classrooms, a one-size-fits-all approach prevails, making it difficult to cater to individual learning needs, paces and styles (Wozniak et al., 2024). Learners who quickly grasp looping concepts may become disengaged, while those who require additional explanation may struggle due to insufficient individualized support.

South Africa's integration of Information Technology (IT) into the matriculation curriculum (Grades 10–12) aims to equip learners with essential digital literacy skills for the modern world (DBE CAPS, 2011; Zhou, Xiong, & Jin, 2021). However, a major challenge arises in the programming section, particularly in understanding looping structures. The complexity of loops discourages many learners, leading them to opt for the more theoretical Computer Applications Technology (CAT) course instead. This issue is reflected in persistently low national exam results for looping concepts, with a reported pass rate of only 42% in 2023 (Diagnosis Report, 2023). This statistics underscore the urgent need for innovative teaching strategies to improve learning outcomes (Zhou, Xiong, & Jin, 2021).

A promising solution to these challenges is the integration of Artificial Intelligence (AI) in IT classrooms, particularly in Gauteng province schools. AI-powered tools can offer personalized learning experiences, adapting to individual learner needs and providing interactive, real-time assistance in understanding looping structures. By acting as a learning aid, AI has the potential to enhance programming instruction and support teachers in making abstract concepts more accessible (Wozniak et al., 2024). Incorporating AI into programming education may significantly improve learner engagement, comprehension, and overall performance, fostering a new generation of IT-literate professionals in Gauteng, South Africa.

1.4.Research Aims

The primary aim of this research is to explore the potential of AI tutoring tools in improving the teaching and learning of looping structures in programming languages, specifically Delphi, within Gauteng Province schools.

1.5.Research Objectives

- To identify how AI can be implemented to enhance the teaching of looping structures within Gauteng Province Schools.
- To analyse the potential benefits and challenges associated with using AI for teaching programming in this context.
- To explore strategies for integrating AI into the programming curriculum while ensuring teachers remain central to the learning experience.

1.6.Research question

- How effective are AI-powered tools in enhancing the teaching and learning of looping structures in programming within Gauteng Province schools?

1.7.Sub Research Questions

- What teaching strategies involving AI-powered tools are currently used to support the teaching of looping structures in Gauteng schools?
- What benefits and challenges do IT teachers experience when using AI tools to teach looping concepts?
- In what ways can AI be integrated into the programming curriculum without displacing the teacher's role?

1.8.Significance of the Study

This study provides valuable insights into the role of Artificial Intelligence (AI) in addressing challenges faced by schools with limited resources. If the AI-powered learning platform (AI-LP) proves effective in enhancing learners' understanding of looping structures, it could serve as a scalable and cost-effective solution for improving computer science education in underprivileged environments. Additionally, this research contributes to the expanding body of knowledge on AI in education by focusing on a specific programming concept within a unique educational context. By examining both the potential and limitations of AI in teaching looping structures, the study offers a nuanced perspective on the integration of AI tools in learning environments. Furthermore, the findings can inform the development of AI-powered learning tools tailored to specific programming concepts, ensuring that these technologies align with pedagogical needs. Lastly, this research serves as a valuable case study for other developing countries exploring AI-driven approaches to computer science education, providing insights that can guide policy and practice in similar educational settings.

Chapter 2: Literature Review

2.1. Introduction

The rapid evolution of Information Technology (IT) necessitates a skilled workforce equipped with programming languages. Mastering these languages relies on a strong foundation in fundamental concepts, including looping structures (Wozniak et al., 2024). Looping structures enable code repetition, automating tasks and building complex programs. However, traditional classroom instruction for looping structures can be challenging for learners to grasp, particularly in resource-constrained environments like South African schools.

This literature review explores the potential of Artificial Intelligence (AI) to address these challenges and enhance the teaching and learning of looping structures within the South African context. The review delves into existing research on the misconceptions that learners have about programming as whole, AI applications in education, focusing on its effectiveness in supporting programming language learning. We will examine the challenges in teaching programming, especially in rural South African schools. The strategies for a successful AI integration in rural Schools. Additionally, we will explore existing initiatives in South Africa that integrate AI, alongside the challenges faced in implementing educational technology solutions within the country's schools. By synthesizing these findings, this review aims to establish a foundation for understanding how AI can be best utilized to improve the teaching and learning of looping structures in South African schools.

The increasing demand for programming skills across industries highlights the importance of equipping South African learners with the necessary competencies to thrive in a technology-driven world (Department of Higher Education and Training, 2023). Addressing the difficulties in teaching looping structures could encourage more students to pursue IT as a subject, leading to higher completion rates and improved performance. This, in turn, would contribute to the development of a skilled workforce capable of meeting the demands of the digital economy.

2.2. Learners' misconceptions about programming and IT

Learners often hold misconceptions about programming, creating barriers to their interest and motivation. These misconceptions include the belief that programming requires exceptional mathematical ability or involves a single universal language. While math skills can be beneficial for certain aspects of programming like algorithm design and data analysis, programming is ultimately about problem-solving, logic, and creativity (Qian & Lehman, 2017).

Additionally, learners might misunderstand the diverse career opportunities opened by programming skills. The demand for programming skills is rapidly growing across numerous fields, not just within traditional computer science domains. From web development and mobile application design to data science and artificial intelligence, programming skills are becoming increasingly essential for various career paths (Swidan, Hermans, & Smit, 2018).

Addressing these misconceptions through effective teaching methods and highlighting the creative aspects and vast applications of programming, such as animation design, web development, and even artificial intelligence itself, is crucial for fostering interest in the field. By scattering these myths and emphasizing the accessibility and problem-solving nature of programming, educators can create a more inclusive and engaging learning environment for students (Qian & Lehman, 2017).

However, even after addressing these general misconceptions, specific challenges arise when teaching fundamental programming concepts like looping structures. Looping structures, while essential for building complex programs that automate repetitive tasks, can be difficult for learners to grasp due to their abstract nature and reliance on concepts like iteration and control flow. Traditional classroom settings, often with large class sizes, can struggle to cater to individual learning paces and styles (Qian & Lehman, 2017). Learners who grasp looping concepts quickly might be left waiting for others to catch up, while those who require more explanation may not receive sufficient individual attention. Additionally, traditional teaching methods may rely on limited practice problems and exercises, hindering learners' ability to solidify their understanding through diverse scenarios and applications of looping structures. These challenges highlight the potential of AI to enhance the teaching and learning of looping structures in South African schools (Swidan, Hermans, & Smit, 2018).

2.3. Looping Structures in Programming

While students might grasp general programming concepts, specific challenges arise when teaching fundamental constructs like looping structures. Looping constructs are a cornerstone of programming, enabling code repetition to automate tasks and build complex programs (Waters, 1979). There are three main types of looping structures commonly encountered in programming languages, namely, For loops, While loops, and Do-while loops. **For loops** execute a block of code based on a predetermined number of times. They typically use a counter variable that starts at an initial value, iterates (increments or decrements) by a specific value, and continues executing the code block until the counter reaches a designated end value. **While loops** continue executing a block of code as long as a certain condition remains true (Waters, 1979).

For instance, you could write a loop that keeps asking the user for input until they enter a valid number. **Do-while** loops are similar to while loops, but the code block is guaranteed to execute at least once, even if the condition is initially false.

These looping structures involve iterating through a sequence of instructions a predetermined number of times or until a specific condition is met (Waters, 1979). However, It is difficult for learners to grasp these looping structures for several reasons. Looping involves abstract ideas like iteration and control flow. Students might struggle to understand how loops work and how to utilize them effectively in problem-solving (Ferdowsifard et al, 2021).

According to Ferdowsifard et al (2021), traditional classroom settings with large class sizes often struggle to cater to individual learning paces and styles. Students who grasp looping concepts quickly might be left waiting for others, while those who require more explanation may not receive sufficient individual attention (Ferdowsifard et al, 2021). Traditional teaching methods may rely on limited practice problems and exercises. Students might not have sufficient opportunities to solidify their understanding through diverse scenarios and applications of looping structures.

These challenges highlight the potential benefits of AI in enhancing the teaching and learning of looping structures in South African schools. AI applications in education have emerged as a promising tool for personalized learning and intelligent tutoring systems. AI algorithms can personalize learning paths for students based on their individual needs and progress (Ferdowsifard et al, 2021). This allows for targeted teaching and practice on looping structures, ensuring students are neither overwhelmed nor under-challenged. Intelligent tutoring systems powered by AI can offer real-time feedback, answer student questions specific to their misunderstandings about loops, and adjust the difficulty level based on student performance. Educational chatbots powered by AI can further enhance accessibility by offering students 24/7 access to learning resources and answering basic questions about looping structures. The integration of Artificial Intelligence in teaching looping structures in South African schools holds immense potential, particularly considering the challenges faced in rural areas .

2.4. Artificial Intelligence and its role in teaching looping structures

While fundamental programming concepts such as looping structures are necessary for developing complex programs, the study indicates that students frequently struggle with them due to their abstract nature and reliance on notions such as iteration and control flow (Okonkwo & Ade-Ibijola, 2023). Traditional classroom environments, which sometimes have huge class numbers, might exacerbate these issues by failing to provide adequate individualized instruction and diversified practice opportunities. Here, Artificial Intelligence (AI) emerges as a promising technique for improving loop structure teaching and learning. One of the key strengths of AI in education lies in its ability to personalize learning experiences (Okonkwo & Ade-Ibijola, 2023). AI algorithms can analyze student data, including performance on coding exercises and quizzes, to identify their strengths, weaknesses, and specific areas where they might be struggling with looping structures. Based on this analysis, AI-powered platforms can personalize learning paths for each student (Rowe, 1988).

AI-powered systems can offer real-time feedback on student code (Alam, 2020). This feedback can go beyond simply identifying errors in syntax (Rowe, 1988). By analysing the logic behind the student's code, AI systems can pinpoint misunderstandings related to looping constructs, such as incorrect initialization of loop counters or flawed loop termination conditions. The feedback can then provide specific guidance on how to rectify these errors and improve the student's understanding of looping structures (Okonkwo & Ade-Ibijola, 2023). Large class sizes in traditional classrooms often make it difficult for teachers to provide sufficient individualized attention to each student. AI-powered platforms can address this gap by offering students personalized instruction and targeted practice opportunities tailored to their specific needs and learning pace. This ensures that no student is left behind or feels frustrated due to a lack of understanding of looping structures (Rowe, 1988).

AI can also power intelligent tutoring systems that act as virtual mentors for students as they learn about looping structures. When a student encounters a looping concept they find challenging, an AI tutor can offer clear explanations and visualizations that break down the concept into simpler steps (Rowe, 1988). The system can also provide interactive examples that demonstrate how different types of loops (for loops, while loops, do-while loops) work in practical scenarios. This can significantly enhance a student's understanding compared to relying solely on textbooks or traditional lectures.

As students work on coding exercises, the AI tutor platform can offer adaptive hints and suggestions (Okonkwo & Ade-Ibijola, 2023). These hints can be subtle and gradually decrease in detail as the student progresses, encouraging them to solve problems independently while providing support when needed. This approach promotes critical thinking and problem-solving skills while ensuring students don't get stuck on challenges related to looping structures. It’s important to note that these Artificial Intelligence platforms do not do the work for the learner but rather come in as a bridge to understanding the fundamentals of looping structures (Alam, 2020).

AI-powered platforms can leverage visualizations and simulations to make the abstract concepts of looping structures more concrete and easier to grasp (Alam, 2020). Students can visualize how loops work step-by-step, see how changes to loop parameters affect the outcome, and gain a deeper understanding of the logic behind loop execution. As students practice with looping structures, AI systems can provide real-time feedback on their code. This feedback can identify errors, suggest potential improvements, and guide students toward writing more efficient and well-structured loops (Okonkwo & Ade-Ibijola, 2023).

The integration of AI-based learning tools for looping structures holds immense potential, particularly considering the challenges faced in rural schools in South Africa (Rowe, 1988). These schools often have limited access to qualified computer science teachers and technological resources. AI-powered platforms can address these limitations by providing consistent and personalized instruction. These AI tutors can offer consistent and personalized instruction on looping structures, regardless of a student's location or access to a qualified teacher (Okonkwo & Ade-Ibijola, 2023). This can significantly improve learning outcomes in rural/township schools where students might not have the same level of resources as their urban equals. AI systems can complement the existing curriculum and expertise of teachers in township schools (Alam, 2020). Teachers can utilize these platforms to personalize learning paths and identify areas where students might require additional support. This can empower teachers to focus on more complex topics or provide individual guidance to students struggling with specific aspects of looping structures (Rowe, 1988).

One of the common difficulties learners encounter in programming is understanding the structural and logical differences between loop types particularly between "for" loops, which execute a fixed number of times, and "while" loops, which rely on a condition that must remain true. Research shows that AI-powered visualisation tools and intelligent tutoring systems can play a critical role in addressing this challenge (Alam, 2020; Jovanovic et al., 2023). For example, platforms like Mind Joy or Python Tutor offer step-by-step code execution visualisations, allowing learners to see the loop's condition being evaluated in real time. When working with "while" loops, AI tools can highlight how the condition is checked before each iteration and how the loop may exit unexpectedly if the condition is not met thereby reinforcing the idea of conditional repetition. In contrast, "for" loops can be demonstrated with counters and predictable ranges, enabling learners to grasp the concept of bounded iteration. Through interactive simulations and AI-generated feedback, learners can debug their logic errors, test different conditions, and ultimately construct deeper mental models of how each loop structure behaves. These functionalities align well with constructivist principles, as they enable learners to actively explore and correct misconceptions through immediate feedback and visual scaffolding.

While internet connectivity can be a challenge in rural areas, some AI-based learning platforms are being developed with offline functionality. These platforms can allow students to download learning modules and practice exercises for use without an internet connection (Alam, 2020). This ensures continued learning opportunities even during periods of limited or no internet access.

However, it's important to acknowledge that integrating AI for teaching looping structures in rural schools also presents challenges. As mentioned previously, internet connectivity can be a significant barrier to utilizing AI-based learning tools in rural areas (Alam, 2020). Strategies for overcoming this challenge might involve downloading learning modules for offline use or exploring low-bandwidth solutions for accessing online platforms. For successful integration, teachers in rural schools might require training on how to leverage AI-powered platforms effectively in their classrooms. This training should focus on using AI tools to complement their teaching, personalize learning paths, and identify student needs related to looping structures (Alam, 2020).

2.5. Conclusion

AI offers a promising solution for enhancing the teaching and learning of looping structures in South African schools, particularly in rural areas facing resource constraints. By providing personalized learning paths, real-time support, and engaging practice environments, AI can empower students to overcome challenges and develop a solid understanding of these fundamental programming concepts (Alam, 2020). However, successful implementation requires addressing challenges related to internet connectivity, teacher training, and infrastructure support (Rowe, 1988). By overcoming these challenges and leveraging the potential of AI, South Africa can create a more inclusive and engaging learning environment for students interested in programming, fostering a future generation equipped with valuable skills for the digital age.

2.6 Research Framework

2.6.1. Introduction

This chapter presents the research framework underpinning this study, which investigates the integration of artificial intelligence (AI) in teaching looping structures in programming within South African schools. The study adopts a dual framework approach: the theoretical framework, based on Constructivism, and the conceptual framework, modeled on the Input-Process-Output (IPO) Model. The Constructivist paradigm informs the study's pedagogical perspective, emphasizing student-centered learning through AI tools, while the IPO model provides a structured approach to understanding how AI tools function in the teaching and learning process.

2.6.2. Theoretical Framework: Constructivism

Constructivism is a learning theory that posits that learners construct knowledge through active engagement and interaction with their environment (Piaget, 1950; Vygotsky, 1978). In the context of programming education, constructivism suggests that students learn best when they actively engage with coding concepts, experiment with problem-solving, and construct their own understanding of programming structures (Jonassen, 1999).

The research adopts Constructivist as the theoretical framework to address the challenges learners face in grasping programming concepts, specifically looping structures. Constructivism, a theory developed by educational psychologists such as Jean Piaget and Lev Vygotsky, emphasizes that learners construct their own understanding and knowledge through experiences and reflecting on those experiences (Piaget, 1970; Vygotsky, 1978). This theory supports active, contextual, and collaborative learning, which aligns with the goals of integrating AI tools in education.

Constructivism is chosen as the theoretical framework for this study because it aligns with the active, hands-on nature of programming education. Teaching looping structures requires students to engage in experiential learning, where they test and refine their understanding through trial and error. AI-powered tools like Mind Joy, ChatGPT, and GitHub Copilot enhance this constructivist learning experience by providing instant feedback, scaffolding, and problem-based learning opportunities (Papert, 1980; Luckin, 2018). Furthermore, constructivism supports collaborative learning, an essential component of modern programming environments, where learners work together to solve coding challenges and refine their skills (Guzdial, 2019).

The framework emphasizes the importance of engaging learners in hands-on activities where they actively participate in their learning process. AI tools can facilitate this by providing interactive programming exercises and real-time feedback. These tools help learners experiment swith looping structures, understand their applications, and learn from their mistakes in a supportive environment. Active learning is crucial for deep comprehension and retention of complex concepts (Prince, 2004).

Constructivism also highlights the value of social interactions in learning. AI-powered platforms can facilitate collaborative learning environments where students can work together on projects, share insights, and solve problems collectively. Such interactions foster a deeper understanding of programming concepts through peer learning and discussion (Vygotsky, 1978). The integration of AI in the educational process aims to increase student engagement and interest in IT subjects. Innovative pedagogical approaches that combine traditional teaching methods with AI-powered tools make learning more dynamic and enjoyable. This increased engagement is expected to improve learning outcomes and encourage more students to pursue careers in technology and engineering (Jovanovic et al., 2023).

2.6.3. Constructivism and AI in Teaching Looping Structures

The teaching of looping structures (e.g., for-loops, while-loops, and recursion) often presents cognitive challenges to learners. Constructivist principles advocate for experiential learning where learners write, test, and debug their own loops rather than simply memorizing syntax (Mayer, 2004). AI tools enhance this process by providing adaptive learning environments where learners receive immediate feedback and can iteratively refine their understanding of looping structures (Luckin, 2018). The choice of a qualitative, interpretive case study design was directly influenced by the constructivist paradigm, which values context-rich, learner-centred experiences. Classroom observations and semi-structured interviews were selected to capture how learners construct knowledge through AI-facilitated interactions. Likewise, the thematic analysis process aligned with the Input-Process-Output (IPO) model by tracing how AI tools (inputs) influence teaching strategies and learner outcomes (outputs). This alignment ensured consistency between theory, data collection, and interpretation.

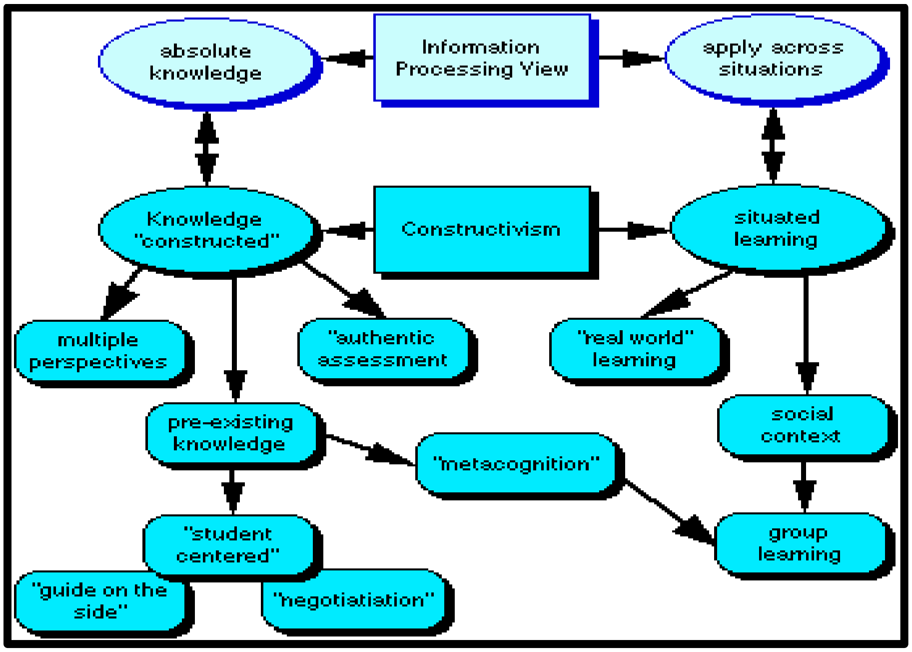


Figure 1: Extracted from Missouri University of Science and Technology Website.
https://web.mst.edu/~rhall/ed_psych/constructivism.html

2.7. Conceptual Framework: Input-Process-Output (IPO) Model

The Input-Process-Output (IPO) Model provides a conceptual lens through which this study examines the role of AI tools in programming instruction. The IPO model categorizes the learning process into three key components; **Input, Process, and Output**. Input: The initial resources and AI-driven tools (e.g., Mind Joy, ChatGPT, GitHub Copilot) introduced to aid in teaching looping structures.vProcess: The interaction between learners, AI tools, and instructional strategies, where learning takes place through hands-on coding, debugging, and iterative problem-solving. Output: The learning outcomes, including improved understanding of loops, enhanced coding skills, and the ability to apply concepts in real-world programming tasks.

The IPO model aligns with constructivist principles by structuring the learning experience into stages that facilitate active engagement and knowledge construction (Mishra & Koehler, 2006). AI-powered platforms provide an interactive learning environment where learners construct knowledge through exploration and guided problem-solving (Vygotsky, 1978). For instance, AI-generated hints and debugging assistance in real-time support scaffolding, a key constructivist strategy. Furthermore, personalized AI-driven feedback helps tailor learning experiences to individual learners, promoting differentiated instruction (Luckin, 2018).

The IPO model operationalizes the principles of constructivism within the study's research design. The Input phase involves the introduction of AI tools (e.g., Mind Joy, ChatGPT, GitHub Copilot) that serve as digital scaffolds. During the Process phase, learners engage in constructivist learning activities such as coding, debugging, and problem-solving central to experiential learning. The Output reflects the constructivist outcome; improved understanding, learner autonomy, and the ability to apply looping concepts in practical contexts. By mapping the learning cycle to IPO stages, the study demonstrates how AI tools facilitate knowledge construction in a structured yet learner-centred manner, thereby bridging the theoretical and conceptual frameworks.

While existing literature has extensively explored the use of artificial intelligence in education, much of this research is centred on higher education contexts, particularly in developed countries, and often focuses on general applications such as adaptive learning platforms, automated grading, or AI-based tutoring (Chen et al., 2020; Mishra & Mehta, 2023). Very little attention has been given to how AI tools can be applied specifically in teaching foundational programming concepts such as looping structures at the secondary school level. Furthermore, there is a notable scarcity of research that examines this within South African school settings, where disparities in digital access and teacher readiness present unique challenges and opportunities. This study addresses that gap by exploring how AI tools such as ChatGPT, Mind Joy, and GitHub Copilot are used or could be used to support the teaching of "while" and "for" loops in secondary schools in Gauteng Province. By documenting real classroom experiences, teacher perceptions, and observed instructional practices, the study provides contextualised insights that can inform both curriculum design and teacher training for AI-enhanced programming instruction in the South African context.

Conclusion

The research framework integrates constructivism as the theoretical foundation and the IPO model as the conceptual model to examine how AI tools enhance the teaching of looping structures in programming. Constructivism provides a pedagogical rationale for active, student-centered learning, while the IPO model offers a structured approach to analyzing the integration of AI in education. This dual-framework approach ensures a comprehensive investigation into the role of AI in programming instruction within South African schools.

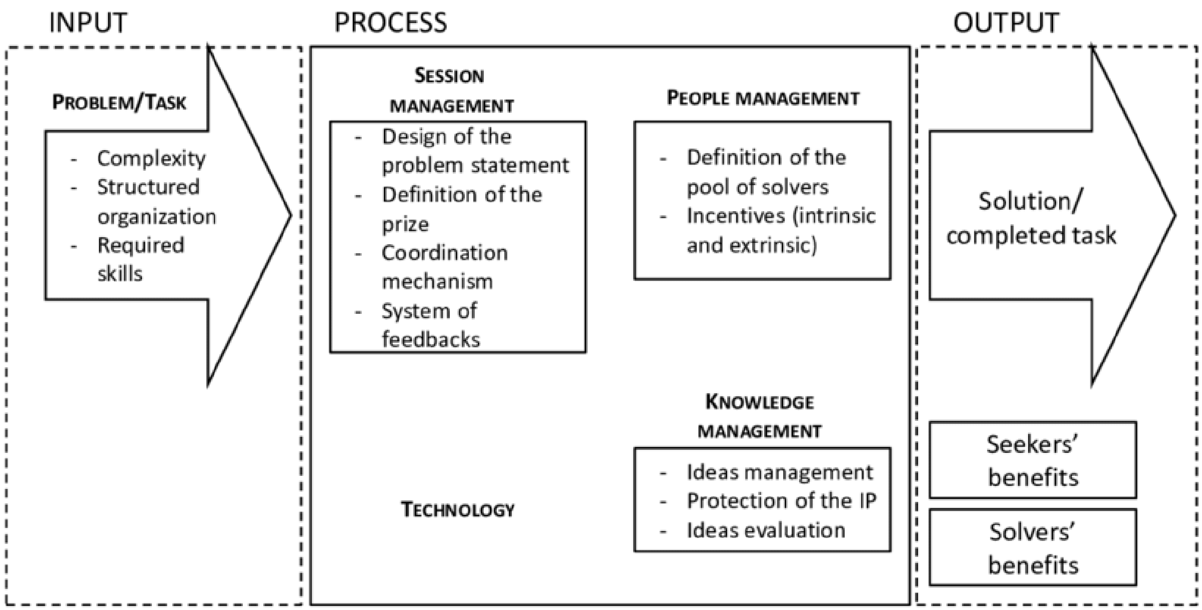


Figure 2: Input–Process–Output (IPO) Model in Relation to AI-Enhanced Constructivist Learning.

Chapter 3: Research Methodology

3.1. Introduction

There are two main methodologies used in data collection and presentation: namely qualitative research and quantitative research (Warfield, 2010). However, before these methods are carried out, the researcher should have a plan, or framework, indicating how the research will be carried out. This is known as research design. This methodology section provides a detailed account of the approach and methods employed in this conceptual and qualitative research (Warfield, 2010). This section outlines the research design, discusses the choice between qualitative and quantitative methods, explains the data analysis process, and addresses ethical considerations. This study is qualitative, with data obtained from participants in their natural surroundings and through their lived experiences. (Warfield, 2010).

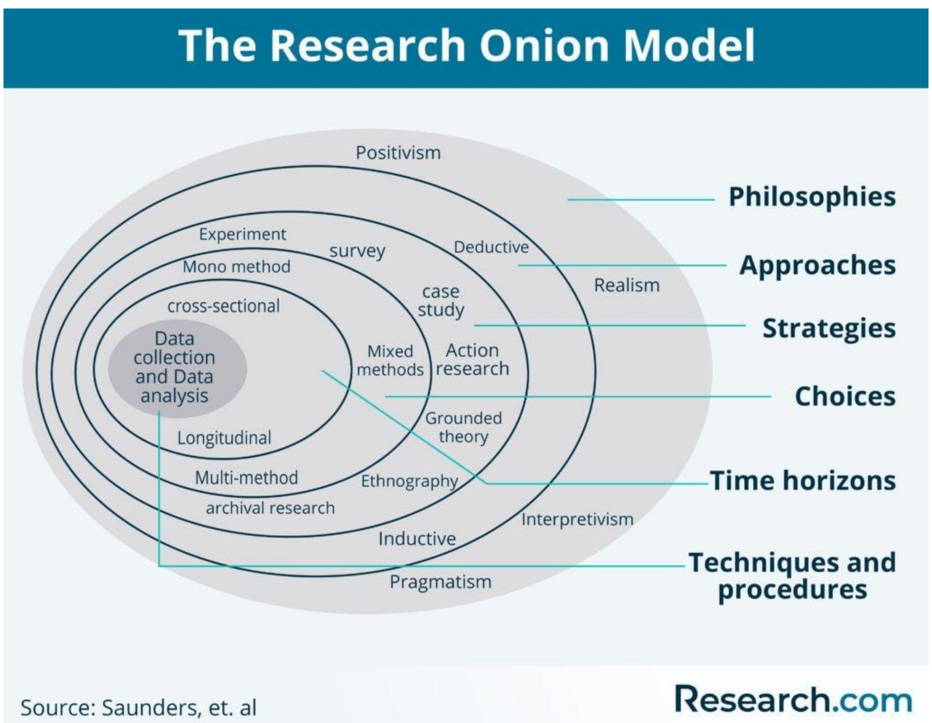


Figure 3: The Research Onion Mode (From: Research.com- Source: Saunders, et.al)

3.2. The Notion of Research

According to Warfield (2010), research is a systematic and organized process of inquiry that seeks to explore, understand, and contribute new knowledge to a particular field or topic. It is a deliberate and methodical investigation that involves asking questions, gathering information, analyzing data, and drawing meaningful conclusions (Warfield, 2010). Research is conducted in various disciplines, including science, social sciences, humanities, and more, and it serves as the foundation for advancing human understanding and addressing complex issues (Johnson & Brown, 2021).

At its core, research is driven by curiosity and the pursuit of answers to unresolved questions or the exploration of uncharted territories (Robinson, 2020). It can take many forms, including empirical studies, theoretical investigations, literature reviews, and conceptual explorations. Research is guided by a structured methodology that outlines the approach, methods, and ethical considerations used to gather and interpret data or information (Jones et al., 2019). Ultimately, the goal of research is to expand our knowledge, inform decision-making, and contribute to the broader body of knowledge within a specific field (Adams, 2018). It plays a fundamental role in advancing society, fostering innovation, and addressing contemporary challenges (Brown, 2017).

3.3. Research methodology and Research design

Research methodology refers to the systematic process, techniques, and procedures used by researchers to conduct a study, gather data, analyze information, and draw conclusions (Noar, 2006). It provides a structured framework for the planning and execution of research projects. Research methodology essentially answers the "how" and "why" of the research process, outlining the steps taken to achieve the research objectives (Noar, 2006).

According to Nayak and Singh (2021), research methodology serves as a research approach that transforms fundamental ontological and epistemological principles into practical guidelines dictating how research should be carried out, encompassing principles, procedures, and established practices governing the research process. It is important to note that there exist diverse research methodologies, with no one-size-fits-all approach applicable to all research inquiries. Each research methodology possesses its unique set of advantages and limitations (Nayak & Singh, 2021). There is no universally superior research methodology, and the choice inevitably entails trade-offs between benefits and disadvantages (Noar, 2006).

3.4. Research Methods

According to Mitchell and Jolley (1998), research methods encompass the particular procedures and approaches employed by a researcher for collecting and analyzing data in the pursuit of research objectives. The selection of research methods is a pivotal component of the research process, contingent upon the specific research questions, objectives, and inherent characteristics of the study (Smith & Johnson, 2023). Put differently, the decision to opt for qualitative or quantitative methodologies hinges on the characteristics of the research queries, the requisite data type, and the level of depth sought in the investigation (Nayak & Singh, 2021). These methodologies diverge significantly in their philosophical underpinnings, data collection techniques, and analytical procedures, offering distinct lenses through which researchers can explore and understand the world.

In this section of research methodology, we will delve into the core principles and characteristics of qualitative and quantitative research, highlighting their strengths and limitations (Nayak & Singh, 2021).

3.4.1. Qualitative methods

Qualitative research is a type of research that explores and provides deeper insights into real-world problems. Instead of collecting numerical data points or intervening or introducing treatments just like in quantitative research, qualitative research helps generate hypotheses as well as further investigate and understand quantitative data. Qualitative research gathers participants' experiences, perceptions, and behavior. It answers the how’s and whys instead of how many or how much. It could be structured as a stand-alone study, purely relying on qualitative data or it could be part of mixed-methods research that combines qualitative and quantitative data (Tenny, Brannan & Brannan, 2017). Qualitative research is primarily exploratory, aiming to uncover, describe, and understand the studied subject in depth (Nayak & Singh, 2021). The qualitative data is typically non-numeric and includes textual information such as interviews, observations, open-ended survey responses, and documents (Nayak & Singh, 2021). Qualitative research acknowledges the subjectivity of the researcher and often involves the researcher's interpretations and reflections in the analysis (Gerring, 2017).

Igwenagu (2016), states that qualitative research aims to explore and understand human behavior, experiences, and phenomena in depth. It seeks to uncover nuances, meanings, and context. It is used to understand concepts, thoughts, or experiences. This type of research enables you to gather in-depth insights on topics that are not well understood (Igwenagu, 2016).

Qualitative research places a strong emphasis on understanding the context in which the studied phenomenon occurs, recognizing that context influences interpretation (Gerring, 2017). It is adaptable to a wide range of research questions and topics, especially those involving human behavior, culture, and experiences. Qualitative research generates rich, contextually embedded data, which can lead to valuable insights (Gerring, 2017). However, Findings from qualitative studies are often context-specific and may not be generalizable to broader populations. The qualitative research methodology involves most vital aspects for a researcher taking this path.

-InDepth Exploration

Qualitative research examines the subject of study in detail and seeks to understand it from a broad perspective. It is not just about scratching a surface; it is trying to discover the complexities, nuances, and complexity of this phenomenon (Gerring, 2017).

-Subjective Interpretation

Qualitative research acknowledges that researchers bring their own perspectives and biases to the study (Gerring, 2017). Interpretation of data is subjective, and researchers often reflect on their role in shaping the findings.

-Flexible Data Collection

Gerring (2017), considers that qualitative research uses flexible data collection methods, allowing for open-ended questions and unstructured interactions with participants. This flexibility encourages participants to share their experiences and perceptions in their own words (Gerring, 2017).

At the heart of grasping qualitative research is the concept that the meaning of phenomena is constructed through the social interactions of individuals within their lived experiences (Nayak & Singh, 2021). Unlike positivist, quantitative research, which often assumes a fixed, singular, universally agreed-upon, and measurable reality, qualitative research recognizes that the world or reality is multifaceted, shaped by diverse perspectives, and not confined to objective measurement. It underscores that our understanding of the world is shaped by the dynamic interplay between individuals and their complex, context-specific social environments (Nayak & Singh, 2021).

The participants in this study will be limited to less than ten (10), because it is carried out in township schools in two districts in Johannesburg, South Africa where there are few schools offering IT. Accordingly, the study will be qualitative in nature as the data will be collected from participants in their natural environment and lived experiences. The data will be collected using interviews and observations. This will allow the study to have access to the actual methods being applied by teachers in teaching the concept of looing structures. The other research method used is the quantitative method.

Figure 4:Qualitative Research Method (Extracted from: penmypaper.com)

3.4.2. Quantitative methods

According to Nayak and Singh (2021), quantitative methods are deductive and aim to test hypotheses, establish relationships, and make predictions (Lerche, 2012). It focuses on quantifiable aspects of phenomena. Quantitative data is numeric and often collected through structured surveys, experiments, or observations with predefined variables. It is used to test or confirm theories and assumptions. This type of research can be used to establish generalizable facts about a topic. The goals of quantitative research are to test causal relationships between variables, make predictions, and generalize results to wider populations (Nayak & Singh, 2021).

Quantitative researchers aim to establish general laws of behavior and phenomenon across different settings/contexts (Lerche, 2012). Research is used to test a theory and ultimately support or reject it. Quantitative research employs standardized instruments, questionnaires, and experiments with closed-ended questions to collect data (Nayak & Singh, 2021). Quantitative data is analyzed using statistical techniques. Researchers use statistical tests to determine the significance of relationships and patterns in the data. However, this method will not be used in this study as data will be collected using interviews and observations and analysed thematically.

3.4.3 Data Collection Instruments

Data was collected using two primary instruments namely, semi-structured interviews and non-participant lesson observations. The semi-structured interviews were conducted with four IT teachers across four Gauteng Province schools. Each interview lasted between 30–45 minutes and included open-ended questions focused on the use of AI tools in teaching looping structures, challenges encountered and observed learner outcomes (see Appendix F).

Observation protocols were developed to guide non-participant observations of programming lessons. A total of five lessons were observed across the four schools. These focused on how teachers incorporated (or did not incorporate) AI tools during looping instruction. The fifth observation occurred in a school where the teacher allowed follow-up access after the interview session.

3.5. Population and Sampling

In research, the population refers to the entire collection of elements (individuals, institutions, events, etc.) that one is interested in studying. The population in this study is teachers who teach IT in two districts of Johannesburg metropolitan. Four (4) teachers were purposively selected from each school within the two districts. While four teachers were interviewed (one per school), five classroom observations were conducted. One school (SCHLD) allowed observation of two separate lessons due to flexible scheduling and the teacher's willingness to demonstrate both traditional and AI-assisted instruction. A method for obtaining information from the study population must be carefully detailed to ensure there are no omissions of part of the target population. A proper collection method should be selected which help obtain the desired information without overly limiting the collected data because many times, the information sought is not well compartmentalized or obtained. Finally, the design should ensure adequate methods for analyzing the data. The better the sample represents the intended study population, the more likely the researcher is to encompass the varying factors.

A sample is a subset of the population that is selected to represent the characteristics of the entire population. Researchers cannot feasibly study the entire population due to practical limitations such as time, resources, or logistical constraints. The goal of sampling is to select a representative sample that accurately reflects the key attributes and variations present in the entire population. By studying this sample, researchers can make inferences about the larger population with a certain degree of confidence. Purposive sampling is selection based on the researcher's rationale for being the most informative (Tenny, Brannan & Brannan, 2017). Purposive sampling was used to select participants with direct experience in teaching programming and access to AI tools. The schools were located in two urban townships within Gauteng Province, ensuring the study reflects both infrastructural challenges and practical teaching realities. This sampling strategy allowed for the capture of rich, context-specific insights relevant to AI integration in resource-limited South African schools.

3.6. Case Study

A case study in research is an in-depth and detailed investigation of a particular individual, group, event, or phenomenon within its real-life context (Brown, 2008). It is a qualitative research method used to gain a comprehensive understanding of complex, multifaceted subjects (Brown, 2008). Case studies are often employed in various fields, including social sciences, business, psychology, healthcare, and education. This case study focuses on the use of Artificial Intelligence in teaching looping structures in programming languages: A case within Gauteng province Schools. (Gagnon, 2010). The aim is to gain a rich, detailed understanding by examining aspects of the case in detail. The case study includes components that guide a researcher.

Context

The context refers to the broader environment, setting, or background in which the case study is situated (Gagnon, 2010). It provides essential details about the conditions and circumstances in which the case study takes place, helping to understand the larger context in which the research is conducted (Gagnon, 2010).

Objective

The objective outlines the specific goals, aims, or purposes of the case study. It clarifies what the study intends to achieve, what questions it seeks to answer, or what aspects of the case it aims to explore or investigate (Brown, 2008).

Analysis

Analysis involves the systematic examination and interpretation of the collected data to derive insights, identify patterns, or draw conclusions about the case (Gagnon, 2010). This process often includes applying specific analytical methods or techniques.

In a nutshell, this case study explores the implementation of an AI-powered learning platform designed to teach or assist with looping structures to learners in Gauteng province. This case study examines how artificial intelligence learning platforms can potentially address these challenges and improve learner learning outcomes in the context of looping structures, a fundamental programming concept.

3.7. Interpretivism Research Paradigm

The Interpretivism Paradigm is a philosophical framework used in social science research that emphasizes understanding the subjective meaning of human experiences. This paradigm contrasts with positivism, which focuses on objective measurement and the discovery of universal laws. Interpretivism asserts that reality is socially constructed and is best understood through the subjective interpretations of individuals (Pervin & Mokhtar, 2022). Epistemologically, interpretivism holds that knowledge is subjective and constructed through social interactions and individual experiences. It posits that the researcher and the researched are interdependent, meaning that the knowledge produced is shaped by the relationship between the two.

Ontology in interpretivism is based on the belief that reality is multiple and constructed by individuals' perceptions and interpretations. It rejects the idea of a single, objective reality that can be measured and quantified (Pervin & Mokhtar, 2022). The interpretive paradigm employs qualitative research methods to gain deep insights into human behavior and social phenomena. Common methods include interviews, focus groups, observations, and case studies. These methods allow researchers to gather rich, detailed data that capture the complexity of human experiences (Pervin & Mokhtar, 2022). The goal is not to generalize findings to larger populations but to provide a deep, contextual understanding of the specific situation being studied. Data analysis in interpretivism typically involves thematic analysis, narrative analysis, or other methods that focus on identifying patterns and meanings within the data.

Interpretivists emphasize the importance of understanding the meaning that people attach to their experiences (Pervin & Mokhtar, 2022). This study examines not just student performance on tests, but also how they perceive the AI-LP as a learning tool, the challenges they face while using it, and the overall impact on their learning experience. Interpretivists primarily rely on qualitative research methods such as interviews, observations, and focus groups to gather rich data on subjective experiences, which is what is going to be used in this study to obtain data (Pervin & Mokhtar, 2022).

Interpretivism research paradigm main aspects

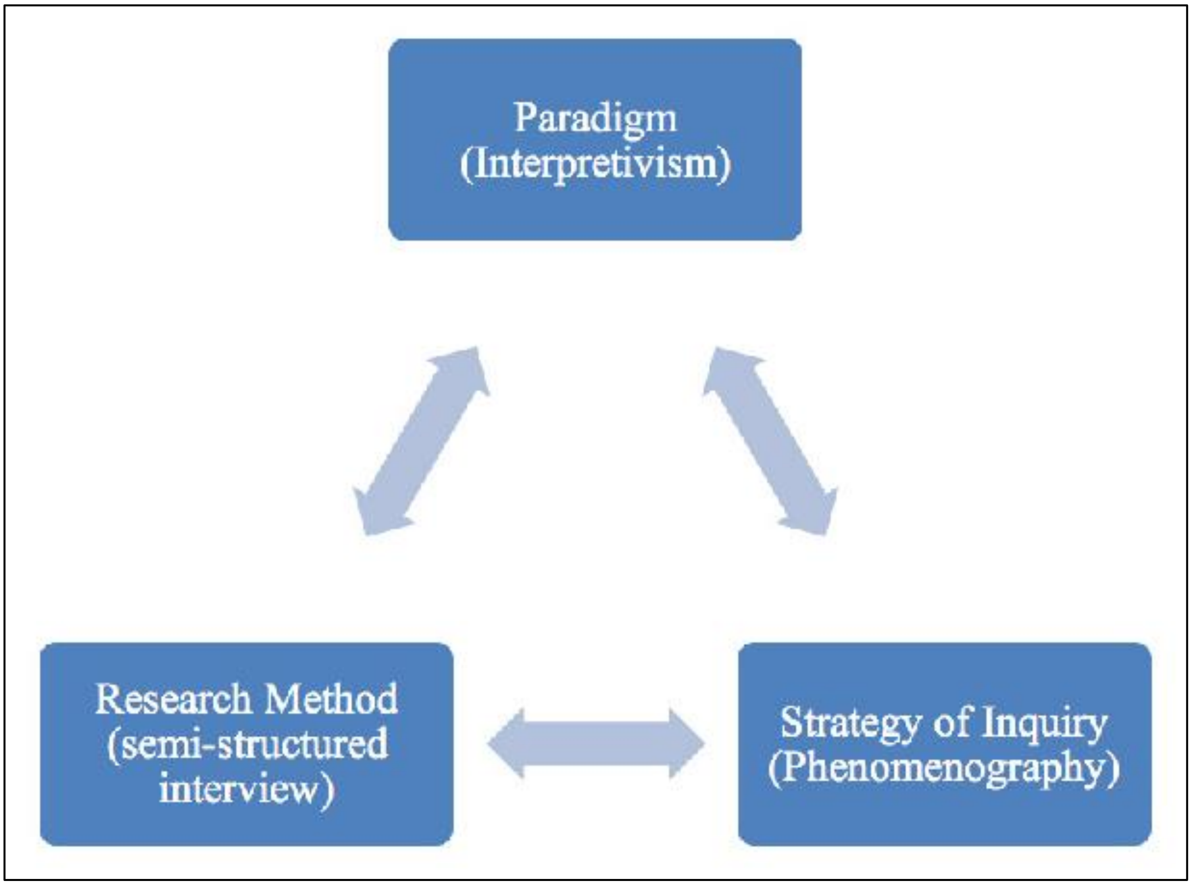


Figure 2: Source: https://www.researchgate.net/figure/Framework-for-a-qualitative-research-design

3.10. Ethical Considerations

Ethical considerations in research are the guiding principles and practices that help ensure the ethical treatment of research participants and maintain the integrity of the research process (Arifin, 2018). They are designed to protect the rights, safety, and well-being of individuals involved in research studies. Ethical considerations are paramount in research and ensure that research is conducted responsibly and with the highest regard for the rights and well-being of participants (Arifin, 2018).

Ethical considerations include issues related to plagiarism and academic integrity. Researchers must ensure that they give proper credit to the sources they consult when developing and presenting their concepts (Arifin, 2018). Failure to do so can lead to accusations of plagiarism and damage the researcher's academic and professional reputation. The planning of this study was driven by a commitment to uphold ethical standards that prioritize the dignity, rights, and well-being of potential research participants. It is important to note that human participants are not involved in this research (Arifin, 2018). For this study ethics application will be applied through the ethics university committee, and this will facilitate the research to be conducted in an ethical manner.

Before data collection commenced, all participants were informed about the purpose of the study. A participation information sheet (Appendix- D) was provided to each participant, outlining the study's objectives. Participation was entirely voluntary, and participants were made aware of their right to withdraw from the study at any point if they chose to do so. To confirm their willingness to take part, consent forms (Appendix- E) were distributed. Additionally, participants were informed that this research was conducted solely for academic purposes and not for personal gain. They were also made aware that no financial compensation would be provided for their participation, but their contribution would be acknowledged anonymously.

To maintain anonymity and confidentiality, the names of participants and their schools were not disclosed. Instead, the schools were assigned pseudonyms such as SCHLA, SCHLB, SCHLC, and SCHLD, while teachers' names were replaced with identifiers like TCR-1, TCR-2, TCR-3, and TCR-4. Participants were reassured that the information gathered during data collection would only be used for the purposes outlined in the information sheet. Furthermore, all interview data would be kept confidential and stored on a password-protected laptop accessible only to the researcher. The data will be securely retained for a period of 3 to 5 years before being permanently erased.

An ethical clearance application was submitted to the University of the Witwatersrand (Wits School of Education), and approval to conduct the research was granted (Appendix-B). Additionally, permission to access schools before data collection was obtained from the Gauteng Department of Education (Appendix-C). To secure consent for the study, letters were sent to the principals of all selected schools. Each participating school provided formal letters granting the researcher permission to carry out the research. This chapter explained the research design, sampling strategy, and data collection processes that guided the investigation.

Chapter 4: Data Presentation and Analysis

4.1. Introduction

This chapter presents and analyses the data collected through semi-structured interviews and classroom observations. The study aimed to explore the use of Artificial Intelligence (AI) in teaching looping structures in programming languages within Gauteng province schools. Data was gathered from Information Technology teachers in four different schools in the Gauteng Province, providing diverse insights into their experiences, challenges, and perceptions regarding AI-driven teaching methods.

The analysis follows a qualitative approach, where thematic coding was used to identify key patterns and trends from the interviews and observations. The findings are organized according to the study's objectives, highlighting how teachers engage with AI tools, the effectiveness of these tools in facilitating the teaching of looping structures, and the challenges encountered. This chapter also includes extracts from interviews and observation notes to support the analysis, ensuring a comprehensive understanding of the data. The data was analysed using Braun and Clarke's (2006) six-step thematic analysis approach, which includes: (1) familiarising with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. This method was appropriate for capturing patterns in both interview responses and observational data and enabled the researcher to interpret how AI tools influence the teaching and learning of looping structures (Braun & Clarke, 2006). The table below shows the summary of the emergent themes and sub-themes.

Theme	**Description**
Traditional Teaching Methods	Dominance of lecture/textbook-based approaches; limited time for AI integration
Limited AI Use in Classrooms	Low adoption of AI tools due to training, infrastructure, and misconceptions
Benefits and Barriers of Using AI	Personalized learning, engagement vs training and digital divide challenges
Future Integration of AI in Curriculum	Teachers' hopes and strategies for future use of AI tools in programming instruction

Balancing Innovation and Tradition	Tension between innovative pedagogy and curriculum deadlines

4.2. Data Presentation

According to Nassaji (2015), data analysis is the process of inspecting, cleaning, transforming, and interpreting data to discover meaningful information, draw conclusions, and support decision-making. It is a crucial phase in the research process, where raw data is turned into actionable insights. In the research, data analysis will involve examining the data collected to understand the phenomena (Christou, 2023).

Key aspects of data analysis in a research context can include, data cleaning, this involves identifying and rectifying any errors, inconsistencies, or missing data in the dataset. Clean data is essential for accurate analysis (Nassaji, 2015). Data transformation, data may need to be transformed to make it suitable for analysis (Nassaji, 2015). This can involve converting data types, aggregating data, or creating new variables. Descriptive analysis, this phase involves summarizing and describing the data. Common techniques include calculating averages, frequencies, and percentages to provide an overview of the data (Nassaji, 2015).

Exploratory Data Analysis (EDA), this is the process of visually exploring data to identify patterns, trends, and outliers. This can be done through charts, graphs, and visualizations (Christou, 2023). Qualitative data analysis, if the research involves qualitative data, such as interviews or open-ended responses, qualitative analysis methods like thematic analysis or content analysis will be used to identify themes, patterns, and meanings within the data (Nassaji, 2015). Interpretation, after conducting the analysis, the results must be interpreted to draw meaningful conclusions. Reporting, the results of the data analysis are typically reported in the findings or results section of the research report.

Data collection was done in 4 different schools with Information Technology (IT) teachers. Pseudonyms or codes were used to ensure the anonymity of the data during data presentation. For schools **SCHL-A** to **SCHL-D** codes were used, representing all the data collection sites. **TCR-1** to **TCR-4** codes were used to represent the teachers who were interviewed. Lastly, for observations the **OBS-1** to **OBS-5** codes were used. The interviews and observations were properly scheduled according to the teacher's timetable and availability, to ensure convenience during the data collection process.

Figure 5: Table 2 shows the codes for schools, Teachers and observations.

Component	**Code**
Schools and IT Teachers	**SCHLA- TCR-1**
	SCHLB- TCR-2
	SCHLC- TCR-3
	SCHLD- TCR-4
Lesson Observations	**OBS-1**
	OBS-2
	OBS-3
	OBS-4
	OBS-5

4.3. Research Themes

A theme in research refers to a central idea, pattern, or recurring concept that emerges from data analysis, particularly in qualitative studies. Themes help researchers organize and interpret data by identifying commonalities and significant insights across responses (Braun & Clarke, 2006). They are essential for understanding participants perspectives and drawing meaningful conclusions. In qualitative research, thematic analysis is often used to identify themes, allowing researchers to categorize and make sense of large amounts of textual data (Nowell et al., 2017).

In this paper the findings indicated that teaching programming in schools is still dominated by traditional methods that do not cater for individual needs. The following themes were established during data collection. Traditional teaching is dominant, AI not effectively used during lesson delivery, Benefits and barriers of using AI, Future integration of AI in the curriculum, and Balancing Innovation and Traditional Methods in Teaching Looping Structures.

4.3.1. Traditional Method of Teaching

Traditional teaching methods symbolize established teaching strategies where the teacher occupies a central role in the educational experience, primarily conveying knowledge through direct instruction, lectures, and memorization (Gagne, 1985). In this model, learners typically function as passive recipients of information, with minimal interaction, critical thinking, or practical engagement. Despite advancements in educational technology, including Artificial Intelligence (AI), the traditional method of teaching remains the primary instructional approach in many schools. In South Africa, the curriculum planners indicate the materials that need to be covered in a specified term. This leaves teachers with no option but to move at a speed that does not accommodate all learners in class. This method is against theories of learning such as cognitivism and constructivism.

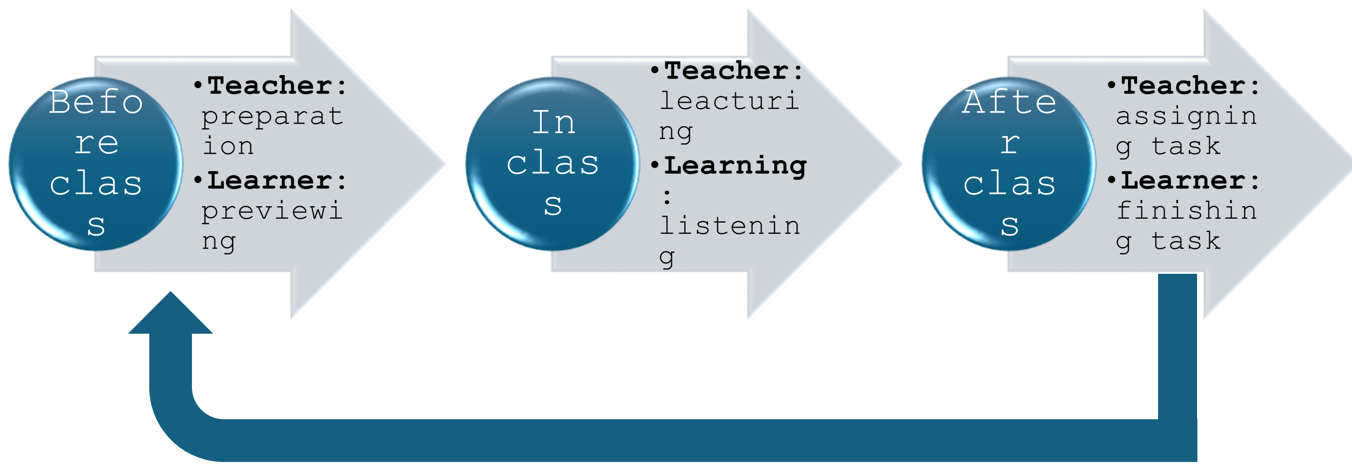


Figure 6: Traditional teaching method diagram

Cognitivism learning theory focuses on how learners process, store, and retrieve information. It emphasizes internal cognitive structures, such as memory, problem-solving, and critical thinking. Unlike behaviourism, which focuses on external stimuli and responses, cognitivism considers how knowledge is actively organized in the mind (Piaget, 1952). This theory suggests that learning occurs when new information is effectively integrated into existing cognitive frameworks, known as schemas (Anderson, 1980).

In the Gauteng schools that were interviewed, programming concepts like loops are taught through direct instruction, with educators explaining syntax and logic on whiteboards while learners passively take in the information (Piaget, 1952; Anderson, 1980). Nevertheless, this method restricts learners from developing problem-solving abilities since they might find it challenging to implement concepts in practical coding scenarios without deeper cognitive involvement.

AI-driven platforms, including ChatGPT and Mind Joy, can enhance a cognitivist approach by offering detailed explanations, helping learners navigate the logical flow of coding structures, and strengthening understanding through interactive activities.

On the other hand, constructivism suggests that learners actively build knowledge influenced by their experiences and existing understanding. Learning is viewed as both a personal and social activity, where learners participate in exploration, reflection, and problem-solving to derive meaning (Vygotsky, 1978). The theory highlights the concept of scaffolding, where educators support learners within their zone of proximal development (ZPD), enabling them to gradually achieve greater independence in their educational journey (Bruner, 1966). The traditional method of teaching does not align with the principles of this learning theory.

Participants confirmed that due to the pressure to meet teaching milestones, the traditional method is quicker compared to the instructional method that relies more on technology which requires more time to prepare. **SCHLA- TCR-1** remarked,

> *Generally, we teach using a traditional method. The department of education requires us to finish some certain topics within a term. This method is faster and does not require a lot of time to prepare.*

SCHLA – TCR-1 indicated that due to time constraints, a traditional teaching method approach is faster as it does not require a lot of preparation. This pressure is originating from above, where they dictate to completion of certain topics within term framework. This sentiment was also echoed by **SCHLB- TCR-2**, **SCHLC- TCR-3**, **SCHLD- TCR-4** respectively.

> *I do mix a bit of technology in my teaching, however, traditional method always prevails. It is faster and allows me to complete the syllabus on time [SKB-TR2].*

> *My teaching is still cantered around use of textbook. Though there is some projectors to project, my method of teaching is still dominated by tradition teaching approach [SCHLC- TCR-3].*

> *Although current teaching and learning theories encourage the use of technology for pedagogical approaches, there are very slow. We can not meet the topics that we should covered during term as required by the department [SCHLD- TCR-4].*

Schools and education systems often resist change due to deeply fixed pedagogical traditions and standardized curricula. The integration of AI requires a shift from teacher-cantered teaching to more learner-driven, interactive learning, which many schools are unwilling to adopt (Chen et al., 2022). Additionally, some educators perceive AI as a threat to their professional roles rather than a tool for enhancing teaching and learning (Selwyn, 2022).

4.3.2. AI Not Effectively Used During Lesson Delivery

The integration of Artificial Intelligence (AI) in education has been recognized as a transformative approach to enhancing teaching and learning experiences (Chen et al., 2022). AI-powered tools have the potential to personalize learning, automate administrative tasks, and improve engagement. However, findings from interviews with Information Technology teachers in Gauteng Province suggest that AI is not being effectively used during lesson delivery. Despite the availability of AI-driven platforms such as Mind Joy, ChatGPT, and GitHub, their application in teaching remains limited due to several challenges, including insufficient training, inadequate infrastructure, and a lack of awareness about AI's pedagogical potential.

TCR-3 from **SCHL-C** clearly indicated that one of the key barriers to effective AI use in teaching is the lack of professional development programs. Many educators are not adequately trained in AI applications or tools and therefore struggle to integrate these tools into their lesson plans. Zawacki-Richter et al. (2019) argue that professional development in AI literacy is crucial for improving teachers' confidence and competency in using AI tools. Without proper training, teachers remain hesitant to adopt AI-driven instructional strategies, relying instead on traditional methods such as lectures and textbook-based teaching.

> *.....what sometimes makes me not to use AI that much in class is the lack of training I would say. For me it's not easy to implement something in class that you as a teacher do not know enough about it.*

Furthermore, there is often a misconception that AI is complex and requires advanced technical skills to implement effectively. Research by Holmes et al. (2021) highlights that many teachers perceive AI as primarily beneficial for administrative tasks like grading, rather than as an interactive teaching tool. This misunderstanding limits the willingness of educators to explore AI-driven solutions for enhancing lesson delivery. This was also indicated by **TCR-2** and **TCR-4** respectively.

> *AI is a good tool to use but I always say that it follows a GIGO principle. Garbage in Garbage out, meaning if you do not know how to prompt it correctly then it will give you incorrect or irrelevant information. The skills and understanding of how to use it is important. [TCR-2]. It once gave me incorrect code when we were dealing with iterations, but I realised later that I'm the one who made an error when I was instructing it [TCR-4].*

The effective use of AI in classrooms requires reliable technological infrastructure, including high-speed internet, modern computing devices, and software accessibility. Many schools, particularly in under-resourced areas, lack these essentials, making it difficult to deploy AI tools effectively. Mishra and Mehta (2023) note that digital inequality remains a significant barrier to AI adoption in education, as schools with limited resources struggle to implement technology-driven teaching methods.

Observations during lessons revealed that even when AI tools were available, their use was sporadic due to connectivity issues, outdated hardware, or restricted access to necessary platforms (Mishra & Mehta, 2023). Without adequate infrastructure, the full potential of AI in lesson delivery cannot be realized, leading to a continued reliance on conventional teaching methods. **TCR-1** from **SCHL-A** clearly indicates that insufficient professional development leads to educators relying on traditional teaching methods rather than integrating AI.

> *The main challenge is that we were never formally trained on how to incorporate them (AI tools) into our teaching. Most of us rely on traditional methods because AI seems complicated. We fear that if we use it incorrectly, it might confuse learners rather than help them.*
>
> *Even when I try using AI in class, connectivity issues often interrupt the flow of the lesson, so I end up switching back to conventional teaching methods*

> *like writing code on the board. I believe AI has potential, but without proper training and reliable infrastructure, it's not practical to use during lessons [TCR-1].*

Another significant challenge on this theme is the limited understanding among educators of how AI can enhance teaching and learning beyond automation. AI has been proven to facilitate personalized learning by adapting content based on student performance, providing instant feedback, and supporting differentiated instruction (Chen et al., 2022). However, teachers often lack exposure to these capabilities and therefore do not fully leverage AI for teaching purposes.

For instance, during **OBS-3** on looping structures in programming, AI tools were not actively used to demonstrate coding principles. Instead, the teacher relied on traditional methods, such as writing code on whiteboards or referring to textbook examples. While these methods are effective to some extent, they do not offer the interactive and adaptive learning experiences that AI-powered tools can provide.

Research by Holmes et al. (2021) suggests that when AI is integrated effectively, it can significantly enhance student engagement and comprehension by providing real-time coding assistance and personalized learning pathways.

4.3.3. Benefits and Barriers of Using AI in Teaching Looping Structures

The theme of Benefits and Barriers of Using AI emerged clearly from the data gathered through semi-structured interviews and classroom observations. This theme focuses on the positive impact and challenges associated with integrating Artificial Intelligence (AI) tools into teaching, particularly when it comes to teaching programming concepts such as looping structures. The data revealed a nuanced understanding of how AI can both support and challenge educational practices in schools, with various advantages and barriers being highlighted.

One of the most significant benefits of incorporating AI in teaching is the ability to provide personalized learning experiences. AI tools, such as ChatGPT and Mind Joy, offer customized content and adaptive learning pathways, allowing learners to engage with material that suits their individual learning needs. According to Selwyn (2019), AI's capability to tailor learning experiences to each learner's strengths and weaknesses has the potential to revolutionize education. In the context of teaching looping structures, AI tools can provide instant feedback and guide learners through complex problem-solving scenarios, ensuring they grasp difficult concepts at their own pace. **SCHLD-TCR-4** echoed this by stating that,

> *I introduced my learners to code.org for debugging the code and get immediate feedback from the platform. This Artificial Intelligence tool has helped my learners in making sure that they get enough time to reflect on the concept we did in class in their own paces. The learners had a problem of understanding how a while loop works with the increase by 1 after each iteration.*

```
var
  num: Integer;
begin
  num := 1;
  while num <= 10 do
  begin
    Writeln('Number: ', num);
    Inc(num);  // Increment num by 1
  end;

  Readln; // Pause the console
end.
```

Figure 7: While loop example from OBS-3

Another major advantage of using AI in education is its ability to increase learner engagement. AI can transform traditionally passive learning environments into interactive, dynamic spaces that encourage learner participation. Bower et al. (2017) explain that AI-enabled platforms often foster a more engaging learning atmosphere by using gamification elements, interactive exercises, and real-time problem-solving.

For learners learning programming, AI tools like GitHub or automated code compilers can provide an immediate response to coding errors, keeping learners actively involved and motivated to troubleshoot and refine their work. This kind of interaction is particularly effective in subjects like programming, where continuous practice and engagement are essential.

> *After I introduced GitHub to the class, most of the learners started to be vibrant when we were doing coding. Some came to me, telling me that now they understand the for loop better because of the platform I gave them. The engagement of learners is impressive every time we do the practical or programming [SCHLD-TCR-4].*

The use AI also improves teaching efficiency by automating administrative tasks. Teachers often spend a considerable amount of time grading assignments, managing resources, and answering repetitive questions. By using AI to automate these tasks, educators can devote more time to teaching and less to administrative duties. Brown & Green (2020) emphasize that the integration of AI in education can reduce the time educators spend on routine tasks, allowing them to focus on more impactful aspects of teaching, such as mentoring and developing interactive lesson plans. AI-powered platforms can also provide quick assessments and feedback on learner progress, helping educators monitor and adjust learning strategies accordingly.

Furthermore, AI serves as a support tool for teachers, helping them manage classrooms more effectively. Many IT teachers report that AI tools assist them in providing real-time feedback to learners, which is especially useful in large classes where individual attention can be challenging. K-12 AI (2020) suggests that AI systems can track learner performance and provide insights that help teachers adapt their teaching strategies to meet diverse learning needs. This level of support is particularly useful when dealing with complex subjects like programming, where learners may struggle with the logical structures of code.

All the participants indicated the importance of Artificial Intelligence in their preparation and sometimes in their teaching. **SCHLA-TCR1**, **SCHLB-TCR2**, **SCHLB-TCR3**, and **SCHLD-TCR4** respectively indicated.

> *With practical activities I sometimes rely on Chatgpt for generation maybe a database that learners will work with. This makes my preparation much more easier and faster [SCHLA-TCR1].*

> *AI come in handy when I do my lesson planning in aligning the concept in order and the practical examples to engage learners in class. [SCHLB-TCR2].*

> *Okay, I do use artificial intelligence when teaching, especially from my lesson planning until these very practical examples that I may use at times. For example, if ever I must loop a structure, a particular structure, or perhaps through a database, and I do not have that database, so it's going to take too much time for me to create the database on my own.But then if ever I use AI, it's going to be a bit quick. It's just going to generate the database really quick, and then I can just use the loops immediately after that [SCHLC-TRC3].*

> *Making the content much more easier for learners to understand I often use AI, If you prompt it well and give It maybe the age group of your learners it can generate an example that maybe most of them will relate on and eventually make they will understand the concept better [SCHLD-TRC4].*

Despite the clear benefits, several barriers to the adoption of AI in teaching were identified during the data collection. A major obstacle is the lack of resources and teacher training. While AI tools have the potential to enhance learning, many teachers lack the necessary skills and knowledge to integrate these technologies into their classrooms. Ertmer (2020) highlights that educators often face challenges in accessing adequate resources or receiving proper training on how to use AI effectively. Without the appropriate training, teachers may not fully understand how AI can be used to benefit learner learning, leading to underutilization or ineffective application of these tools.

Another significant barrier is resistance to change. Many educators are hesitant to embrace new technologies, particularly when they are unfamiliar with them. Garrison and Akyol (2022) argue that resistance to adopting AI is common in educational settings, especially when teachers feel that their traditional teaching methods are being undermined. This resistance can be attributed to a variety of factors, including a lack of confidence in using AI tools, fear of obsolescence, or simply a preference for traditional teaching methods that have proven effective over time. Teachers may also worry that AI could replace their roles or lead to diminished student-teacher interaction, which is essential for building meaningful relationships with learners.

During **OBS-4** the learner in class asked the teacher about the AI tool that they can use to for understanding the while loop. The teacher was not familiar with the tool and was not willing to give it or the learner a chance to see how it can be beneficial. Reliability and limitations of AI tools also pose a significant challenge. While AI can offer immediate feedback and personalized learning, its effectiveness is often limited by the quality and accuracy of the tools themselves. Research by Luckin et al. (2019) reveals that AI systems sometimes struggle with context-aware decision-making, making them less adaptable in certain teaching situations. For instance, AI tools may fail to recognize when a learner is struggling with a deeper conceptual issue, such as the logic behind looping structures, and thus cannot provide the nuanced guidance a teacher might offer. This limitation restricts the potential of AI as a comprehensive teaching assistant.

4.3.4. Future integration of AI in the curriculum.

The theme of Future Integration of AI in the Curriculum emerged as a significant finding from the data collected through interviews and classroom observations. As artificial intelligence (AI) continues to evolve, its role in education is becoming more evident, prompting discussions on how best to incorporate AI-driven tools and methodologies into school curricula. The integration of AI into the teaching of programming concepts, such as looping structures, offers both opportunities and challenges. This section explores the potential frameworks for integrating AI into the curriculum, the necessary skills teachers and learners must develop, and the challenges that need to be addressed to ensure successful implementation.

AI is becoming an essential component of many schools, making it crucial for Gauteng province schools to prepare learners for an AI-driven world. According to Luckin et al. (2018), AI literacy should be viewed as a core competency, similar to digital literacy, as AI is increasingly shaping the way people work, interact, and solve problems. Interviewees echoed this sentiment, with **SCHLB-TCR2** stating:

> *We can't ignore AI anymore. If we don't start incorporating it into our curriculum now, we'll be leaving our learners behind. They need to understand not just how to use AI, but also how it works and how it can be applied in real-world scenarios.*

One major motivation for incorporating AI is its ability to improve computational thinking. According to Wing (2017), computational thinking is an essential skill that empowers learners to tackle problems in a logical manner. AI tools like Mind Joy and GitHub support this by enabling learners to engage with AI-generated code recommendations, evaluate AI-assisted debugging solutions, and test various programming structures. Moreover, AI supports adaptive learning, where AI-driven platforms personalize educational content based on each student's strengths and weaknesses. Holmes et al. (2019) suggest that AI can be leveraged to create individualized learning experiences, ensuring that learners struggling with specific programming concepts, such as nested loops, receive targeted assistance.

> *With AI, students are getting instant feedback on their code. This speeds up their learning process because they can quickly identify and*

correct errors instead of waiting for me to check each program manually [SCHLB-TCR-2].

Some learners struggle with understanding loops, but AI tools like ChatGPT can explain the same concept in different ways until they get it. It's like having a tutor available 24/7 [SCHLC-TCR-3].

Frameworks for AI Integration in the Curriculum

For AI to be effectively integrated into school curricula, a structured approach must be adopted. Selwyn (2019) suggests a framework that includes teacher training, curriculum redesign, and infrastructure development. **Teacher Professional Development** many teachers lack the necessary knowledge of AI and its applications, making it difficult for them to teach AI-related concepts effectively (Ertmer & Ottenbreit-Leftwich, 2020). One interviewee highlighted this challenge:

I think the biggest barrier to AI integration is that many teachers, including myself, don't fully understand AI. We need proper training to know how to use these tools effectively in our teaching [SCHLD-TCR-4].

The future integration of AI in the curriculum presents both opportunities and challenges. AI has the potential to enhance computational thinking, personalize learning, and improve learner engagement, making it an essential component of modern education. However, successful integration requires a structured approach that includes teacher training, curriculum redesign, and investments in technological infrastructure. Educators and learners must develop essential AI-related skills, while challenges such as teacher resistance, data privacy concerns, and digital inequalities must be addressed. As AI continues to reshape education, schools must take proactive steps to ensure that all students can benefit from AI-enhanced learning environments.

4.3.5. Balancing Innovation and Traditional Methods in Teaching Looping Structures

In the evolving landscape of programming education, the integration of Artificial Intelligence (AI) presents both opportunities and challenges. AI-powered tools, such as ChatGPT, Mind Joy, and GitHub Copilot, are being increasingly used to support teaching and learning in programming (Luckin, Holmes, Griffiths & Forcier, 2023). However, while these tools offer innovative solutions, they should complement; not replace traditional teaching methods. This balance is essential to ensure that learners develop both conceptual understanding and problem-solving skills (Mikroyannidis et al., 2022).

The Role of AI in Teaching Looping Structures

AI-powered tools provide an innovative way to assist learners in understanding programming concepts, particularly in complex topics like looping structures. **TCR -1** from **SCHL-A** acknowledged the benefits of AI for reinforcing syntax and logic in Delphi programming. Specifically, ChatGPT was utilized for Practical Assessment Tasks (PATs), where learners could engage with AI-generated code, analyse it, and apply it to real-world problems. The effectiveness of this approach aligns with existing literature, which suggests that AI-driven learning environments can enhance computational thinking and problem-solving skills (Zawacki-Richter et al., 2019). The improved learner performance observed during PATs in this study can be attributed to a combination of AI-driven assistance and repetitive practice, as recommended by pedagogical frameworks for AI-assisted learning (Holmes et al., 2021). **TCR -1** from **SCHL-A** in support for the above clearly stated as follows.

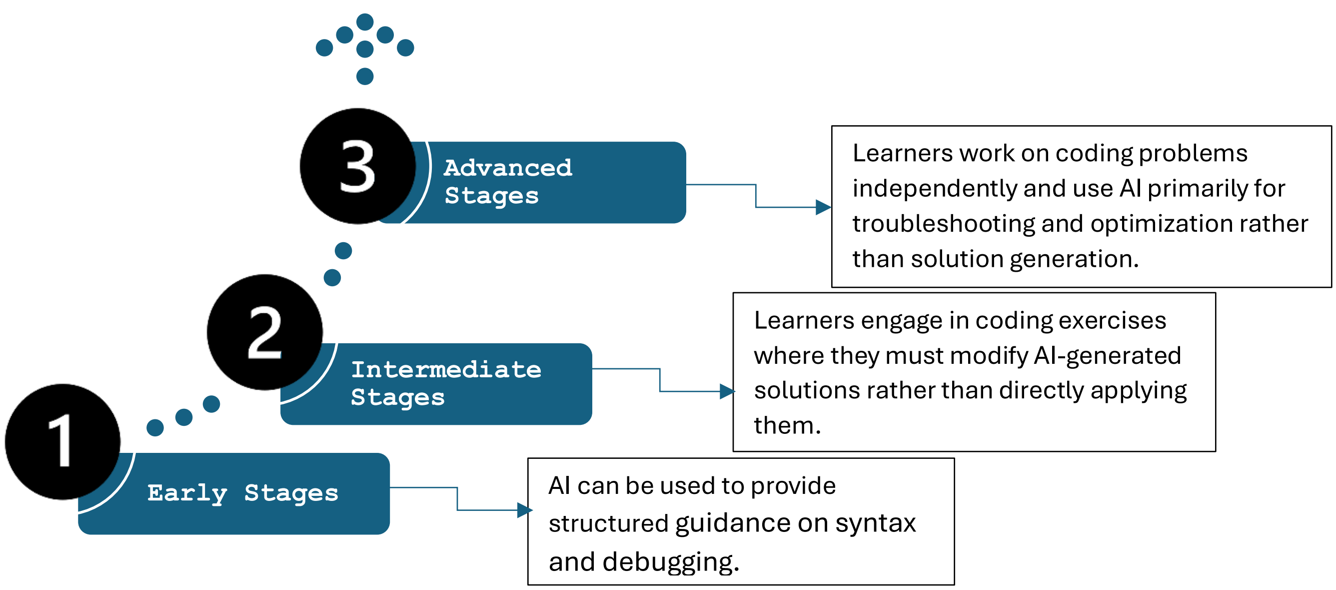
> *So the reason why is because when you give ChatGPT a situation and then you ask it to solve , it's just going to give you the code and there is minimal explanation into the syntax and the logic behind it, it just gives you the code, the answer. So that's why I discourage them from using it when we are doing the daily exercises and activities. But for PAT, I do encourage it because we are working on time and usually they want like complex coding and the reason why I do it is because once you know the logic and the syntax behind each coding that you are going to use, it's easy for you to understand the answer or the code that ChatGPT will give you and it will be easy for you to edit it to show your way of thinking instead of just copy and paste, which is what I don't like.*

Preventing Over-Reliance on AI

One major concern raised during the data collection was the risk of learners becoming overly dependent on AI. Studies indicate that while AI can facilitate understanding, it may also lead to cognitive offloading, where learners rely on AI for answers rather than developing deep knowledge (Selwyn, 2022). **TCR-1** mitigated this risk by implementing controlled AI usage, ensuring that AI was integrated into structured exercises rather than daily activities. This aligns with the curriculum advocating for a scaffolded approach to AI in education, where AI serves as a cognitive tool rather than a knowledge substitute (Luckin, 2018).

Scaffolding in AI-supported learning involves **gradual reduction of AI dependence** as learners build confidence in their coding abilities. This approach ensures that AI remains a learning aid rather than a replacement for traditional programming skills. Research supports this view, emphasizing that effective AI integration should promote computational thinking, problem-solving, and critical analysis, rather than passive consumption of AI-generated outputs (Luckin et al., 2016; Holmes et al., 2021).

Figure 8: AI Scaffolding



The diagram above shows stages of scaffolding in AI-supported learning.

Additionally, teaching AI literacy is a crucial component of this process. AI literacy involves understanding how AI tools work, their limitations, and how to critically engage with AI-generated content. **TCR-2** from **SCHL-B** highlighted the importance of teaching learners how to evaluate AI outputs, cross-check AI-generated solutions with their own logic, and refine code independently. This aligns with recent educational frameworks that advocate for AI-enhanced learning while maintaining human cognitive engagement (Mikroyannidis et al., 2022). **TRC-2** on learners relying on AI stated that:

> *Okay. Well, I do use it. However, it's something that I don't want to encourage the kids to look at right now because they tend to focus more or to rely more on this tool. However, for my assessments, I do use AI, there's one called GitHub. I do use that one because it has features where learners can upload their code and then they start to realize or see where the errors are in the different lines of code.*
>
> *So I wouldn't say it's for a lesson, but then it does teach them something to know where the errors are and to be able to solve or look at the problem and break it down to solve and go away with those errors. But it's not something that I've implemented in my lessons. It's just for my assessments. I use it and then it helps them to learn or to understand the way to expect errors.*

4.4. Data Analysis

Data analysis in research refers to the process of systematically examining, organizing, interpreting, and presenting collected data to derive meaningful insights and conclusions. It involves applying statistical, qualitative, or computational techniques to identify patterns, relationships, and trends that help answer research questions (Creswell & Creswell, 2023). This paper which involves semi-structured interviews and observations of AI integration in teaching, data analysis primarily focus on qualitative thematic analysis. This approach helps in categorizing responses into meaningful themes. Thematic analysis ensures that patterns emerging from the interviews and classroom observations are systematically examined and supported by relevant literature (Braun & Clarke, 2021).

Thematic analysis is a systematic process of identifying, analyzing, and interpreting patterns of meaning within qualitative data like interview transcripts, learner feedback, or teacher observations (Christou, 2023). It helps the researcher move beyond a simple description of the data to uncover deeper insights into the experiences and perspectives of participants related to the AI learning platforms.

The first theme that emerged highlights the underutilization of AI tools such as Mind Joy, ChatGPT, and GitHub in the teaching process. Teachers reported that they were aware of AI-based platforms but struggled to integrate them effectively due to insufficient training and lack of confidence in using AI pedagogically. Classroom observations confirmed that traditional methods, such as whiteboard explanations and textbook-based teaching, were still the dominant approach. Despite advancements in AI, many teachers continued to rely on traditional teaching methods. This was attributed to the absence of structured AI training, concerns about AI reliability, and resistance to technological change. Research by Holmes et al. (2021) supports this finding, emphasizing that teachers often default to familiar instructional methods when faced with technological uncertainty.

Participants cited multiple challenges preventing AI from being effectively integrated into lesson delivery. (1) **Lack of Teacher Training**, most educators had not received formal training in AI-based instructional methods, making adoption difficult (Zawacki-Richter et al., 2019). (2) **Inadequate Technological Infrastructure** schools lacked stable internet connections and the necessary hardware to support AI tools. (3) **Limited Awareness of AI's Pedagogical Benefits** teachers often associated AI with administrative functions rather than interactive learning enhancement (Chen et al., 2022).

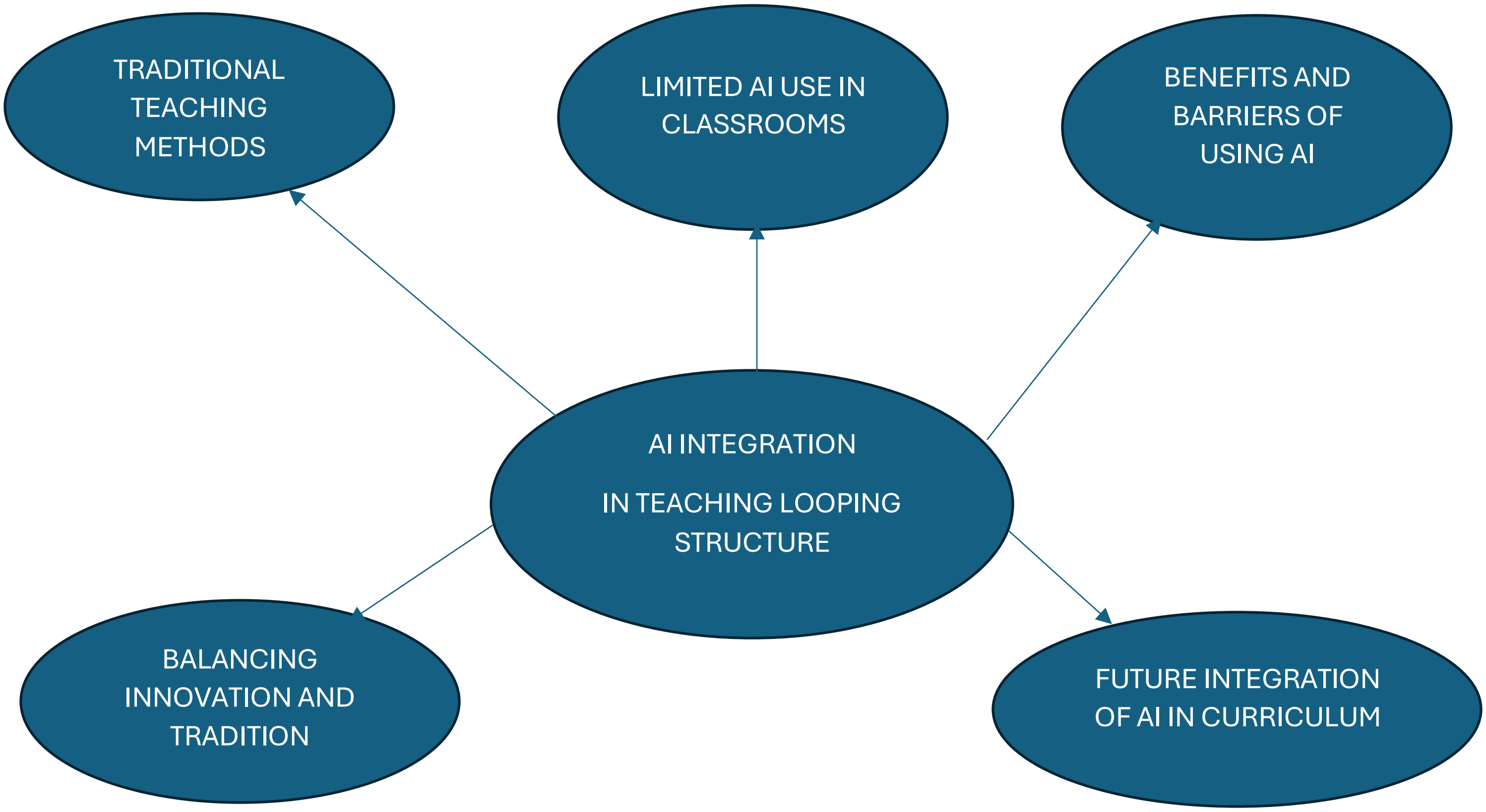


Figure 9: The relationship within themes

4.5. Conclusion

Despite the challenges, teachers acknowledged AI's potential in improving learner engagement and personalized learning. Some participants believed that AI-powered tools could enhance programming instruction by providing instant feedback and adaptive learning pathways, as suggested by Mishra and Mehta (2023). However, without proper implementation strategies, these benefits remain largely theoretical.

The data analysis revealed that AI is not effectively used during lesson delivery due to various structural and pedagogical challenges. Traditional teaching methods continue to dominate, largely due to a lack of training, inadequate infrastructure, and limited awareness of AI's benefits. Addressing these issues through targeted professional development, technological investment, and awareness campaigns can facilitate the meaningful integration of AI into programming instruction. The thematic findings revealed both opportunities and challenges in using AI tools for teaching looping structures. The next chapter discusses these findings in light of the theoretical framework and literature, drawing out their implications for practice and policy.

Chapter 5: Discussion and Response to the research question

5.1. Introduction

This chapter provides an in-depth discussion of the study's findings in relation to existing literature on AI integration in teaching programming concepts, particularly looping structures. The discussion reflects on the key themes that emerged from the data analysis and explores their implications for teaching practices. This section also aims at providing findings that intends on answering the research question: “Which AI tools and resources are most effective for teaching looping structures in schools within Gauteng Province?” with the following sub-questions:

- *How can AI be effectively implemented to enhance the teaching and learning of looping structures in Gauteng Province schools?*
- *What are the specific benefits and challenges of using AI for teaching looping concepts in this context?*
- *How can AI be integrated into the South African programming curriculum for looping structures while ensuring teachers remain central to the learning process?*

Additionally, this chapter presents recommendations aimed at enhancing the effective use of AI in lesson delivery, overcoming the challenges identified, and promoting AI literacy among teachers.

5.2. Discussion

In research, the discussion section interprets and explains the significance of findings in relation to the research objectives, existing literature, and theoretical framework. It provides an analytical perspective on the results, identifying patterns, contradictions, and implications. According to Creswell and Creswell (2018), the discussion section serves to contextualize findings, highlighting their contribution to knowledge while acknowledging limitations and suggesting areas for future research. Similarly, Braun and Clarke (2021) emphasize that a well-structured discussion synthesizes data analysis with broader theoretical perspectives, demonstrating how the study advances understanding in the field.

The findings indicate that despite the availability of AI tools such as Mind Joy, ChatGPT, and GitHub, their integration into lesson delivery is minimal. The main reasons identified include insufficient teacher training, inadequate infrastructure, and a lack of awareness about AI's pedagogical benefits. These findings align with Holmes et al. (2021), who emphasize that AI adoption in education is hindered by teachers limited understanding of its instructional potential. The study revealed that many IT teachers continue to rely on traditional teaching methods, such as direct instruction and textbook-based learning, even when AI resources are available. This trend is consistent with Zawacki-Richter et al. (2019), who found that educators often hesitate to adopt AI due to the perceived complexity of implementation and a preference for familiar instructional strategies. While traditional methods have their merits, they may not fully support the interactive and adaptive learning experiences that AI can facilitate.

The research identified several benefits of AI-driven instruction, including personalized learning experiences, instant feedback, and increased student engagement. However, challenges such as inadequate technological infrastructure, resistance to change, and the digital divide were also noted. These findings are supported by Mishra and Mehta (2023), who highlight the need for targeted interventions to bridge the gap between AI's potential and its practical application in under-resourced schools.

5.2.1. Response to the Research Question and Research sub-questions

The primary research question of this study seeks to determine which AI tools and resources are most effective for teaching looping structures in Gauteng Province schools. The discussion section addresses this question by analysing the data collected through semi-structured interviews and observations, and comparing these findings with existing literature on AI in education. The study highlights how AI-powered platforms such as Mind Joy, ChatGPT, and GitHub can be leveraged to support learners in understanding looping structures. These tools offer features such as real-time feedback, debugging support, and personalized learning pathways, which are essential in helping students grasp complex programming concepts. However, despite these potential benefits, the findings indicate that AI is not yet being fully utilized during lesson delivery.

To explore the effective implementation of AI in teaching looping structures, the study examines the key factors that influence AI adoption in classrooms. One of the major themes that emerged from the data analysis is the lack of teacher training and confidence in AI integration. Many teachers expressed uncertainty about how to incorporate AI tools into their lessons, largely due to insufficient professional development. This finding aligns with previous research (Holmes et al., 2021), which emphasizes that without proper training, educators struggle to transition from traditional methods to AI-assisted teaching. The discussion section elaborates on the need for targeted AI training programs, highlighting that successful AI adoption depends on equipping teachers with the necessary skills to use these technologies effectively.

The research further explores the specific benefits and challenges of using AI for teaching looping structures in Gauteng Province schools. AI has been found to improve engagement and personalized learning, allowing students to receive instant feedback and tailored learning experiences based on their progress. However, several barriers hinder its full implementation, including inadequate infrastructure, resistance to technological change, and a lack of awareness about AI's pedagogical potential. These challenges are consistent with findings from Zawacki-Richter et al. (2019), who stress that without adequate resources and institutional support, AI integration in education remains superficial. The discussion provides a balanced perspective by recognizing both the potential and the limitations of AI in teaching programming concepts.

Another critical aspect the discussion addresses is how AI can be integrated into the South African programming curriculum for looping structures while ensuring that teachers remain central to the learning process. The study suggests a blended learning approach, where AI tools are used to enhance traditional teaching rather than replace educators. This approach ensures that AI remains a complementary resource, allowing teachers to focus on higher-order thinking skills while AI provides adaptive learning support and practice exercises. The discussion further highlights that, for AI to be fully embraced, there is a need for clear policy guidelines, curriculum adjustments, and collaboration between educators, policymakers, and technology providers.

How can AI be effectively implemented to enhance the teaching and learning of looping structures in Gauteng Province schools?

The effective implementation of Artificial Intelligence (AI) in teaching looping structures requires a combination of interactive tools, adaptive learning techniques, and teacher involvement. AI-powered platforms such as Mind Joy provide a visually engaging environment where learners can practice coding loops interactively. The findings indicated that these platforms use real-time simulations to help leaners understand how loops function in a program.

Additionally, AI enhances learning by offering adaptive learning experiences, where tools like ChatGPT and GitHub Copilot analyze a learner's progress and provide customized exercises. This personalized approach ensures that students who struggle with loops receive targeted assistance while advanced learners are challenged with more complex tasks.

The effective implementation of Artificial Intelligence (AI) in teaching looping structures requires a combination of interactive tools, adaptive learning techniques, and teacher involvement. AI-powered platforms such as Mind Joy provide a visually engaging environment where learners can practice coding loops interactively. These platforms use real-time simulations to help students understand how loops function in a program. Additionally, AI enhances learning by offering adaptive learning experiences, where tools like ChatGPT and GitHub Copilot analyze a learner's progress and provide customized exercises. This personalized approach ensures that students who struggle with loops receive targeted assistance while advanced learners are challenged with more complex tasks.

Another key aspect of AI implementation is real-time feedback and debugging support. AI-powered assistants help learners identify and correct errors in their looping structures, reducing frustration and reinforcing problem-solving skills. Furthermore, gamification techniques can make learning more engaging by integrating AI-driven coding challenges, competitions, and interactive exercises that encourage continuous practice. However, to ensure successful implementation, teachers must be trained to use AI tools effectively. Professional development, programs should focus on integrating AI into lesson plans while maintaining traditional teaching methods to provide a well-rounded learning experience.

What are the specific benefits and challenges of using AI for teaching looping concepts in this context?

The use of AI in teaching looping structures presents numerous benefits that enhance both teaching efficiency and student learning. One significant advantage is personalized learning, where AI adapts to individual learner's needs, providing explanations and exercises based on their skill levels. AI tools also offer instant feedback, allowing learners to correct their mistakes and improve their coding skills in real-time. Additionally, AI platforms enhance student engagement by using interactive coding exercises that make abstract programming concepts more accessible. From a teacher's perspective, AI can reduce workload by automating tasks such as assessing learners exercises, generating personalized lesson plans, and offering additional explanations where necessary.

Despite these advantages, AI integration in programming education comes with several challenges. Limited access to technology remains a significant barrier, as not all schools in Gauteng Province have the necessary infrastructure, such as reliable internet connectivity and devices, to support AI-powered learning. Additionally, teacher readiness poses a challenge, as many educators may lack the necessary skills and confidence to incorporate AI into their teaching. Another concern is the over-reliance on AI, where students might depend too much on AI-generated solutions without fully understanding the logic behind loop structures. Finally, ethical considerations must be taken into account, as AI tools may sometimes produce incorrect or inefficient code, requiring continuous teacher oversight to ensure students develop accurate programming skills.

How can AI be integrated into the South African programming curriculum for looping structures while ensuring teachers remain central to the learning process?

For AI to be successfully integrated into the South African programming curriculum, it must complement rather than replace traditional teaching methods. One essential approach is curriculum alignment, ensuring that AI tools support existing lesson plans while reinforcing core programming concepts. Teachers should incorporate AI as a supplementary tool, using it to enhance explanations, generate coding exercises, and facilitate personalized learning. A blended learning approach is recommended, where teachers first introduce looping concepts through traditional methods such as flowcharts and pseudocode before allowing learners to explore AI-assisted coding environments. This ensures that learners develop a deep understanding of loops rather than relying solely on AI-generated solutions.

Additionally, AI can be used to assist lesson planning, helping teachers create engaging coding exercises, quizzes, and assessments tailored to students' progress. However, for this integration to be effective, teacher training programs must be implemented to equip educators with the necessary skills to manage AI-enhanced classrooms. The South African Department of Education should introduce professional development initiatives focusing on AI literacy, enabling teachers to guide students effectively while maintaining their role as the primary facilitators of learning. Schools should also establish ethical guidelines for AI use, ensuring that

AI serves as an instructional aid rather than a replacement for human instruction. By striking a balance between AI-driven learning and traditional teaching strategies, educators can enhance the teaching of looping structures while retaining their critical role in shaping students' computational thinking skills

5.3. Conclusion

The study has demonstrated that while AI tools such as Mind Joy, ChatGPT, and GitHub have the potential to enhance lesson delivery, provide personalized learning, and support learners in debugging and problem-solving, their effectiveness remains limited due to various challenges. Teachers' lack of training and confidence, inadequate infrastructure, and limited awareness of AI's pedagogical benefits have emerged as major barriers to effective implementation. These findings align with previous research that emphasizes the need for comprehensive teacher training and institutional support to facilitate AI adoption in education (Holmes et al., 2021; Zawacki-Richter et al., 2019).

Moreover, the discussion has demonstrated that while AI offers innovative learning experiences, it should complement rather than replace traditional teaching methods. A blended learning approach, where AI serves as a supporting tool for educators, is essential in ensuring that technology enhances rather than diminishes the role of teachers in the classroom. This study also emphasizes the need for policy reforms and strategic investments to create an environment where AI can be effectively integrated into the South African programming curriculum for looping structures.

Ultimately, the findings provide valuable insights into the potential of AI in programming education, while also highlighting the critical steps required for its successful implementation. By addressing the identified challenges and leveraging AI's benefits, schools can enhance the teaching and learning of looping structures, fostering improved learner engagement and comprehension. The recommendations presented in this study will serve as a guide for educators, policymakers, and stakeholders in ensuring AI's effective and sustainable use in Gauteng Province schools.

Chapter 6: Study Limitations, Recommendations and Conclusions

6.1.Introduction

This chapter summarizes the study's key findings while discussing its limitations, offering recommendations, and presenting the overall conclusions. The study explored the integration of Artificial Intelligence (AI) tools in teaching looping structures in programming within Gauteng Province schools. The findings revealed that while AI holds significant potential for enhancing programming education, its implementation remains limited due to various challenges, including a lack of teacher training, inadequate technological infrastructure, and limited awareness of AI's pedagogical benefits.

This chapter first outlines the limitations that affected the study's scope and generalizability. It then provides recommendations aimed at addressing the challenges identified, particularly focusing on enhancing teacher preparedness, improving access to AI tools, and refining policy approaches. Finally, the conclusion summarizes the study's contributions, reinforcing the need for AI to be integrated effectively in South African schools to bridge the digital divide in programming education.

6.2. Study Limitations

Despite its contributions, this study had several limitations that must be acknowledged. A major limitation was time constraints, which restricted the ability to conduct long-term observations of AI-integrated lessons. The study only captured AI usage during a limited number of class periods, making it difficult to assess its long-term impact on learner performance and engagement. Future research should consider longitudinal studies that track AI's effectiveness over an extended period. Another significant limitation was the small sample size, as the research focused on four schools within Gauteng Province. While this provided valuable insights, the findings may not be fully representative of all schools across South Africa, particularly those in rural or under-resourced areas where AI access and implementation challenges may differ. A larger and more diverse sample could offer a more comprehensive understanding of AI adoption in various educational settings.

Additionally, the availability of AI tools varied across the observed schools. Some teachers had access to platforms such as Mind Joy, ChatGPT, and GitHub, while others faced restrictions due to lack of licenses, limited internet access, or outdated computer systems. This disparity affected the consistency of AI usage, making it challenging to compare AI's impact across different schools. To fully understand AI's role in education, future studies should ensure equal access to AI tools across research sites.

Lastly, differences in teacher expertise and training influenced AI adoption. Some educators had prior exposure to AI and felt comfortable experimenting with it in their lessons, while others lacked the confidence and technical knowledge to integrate AI effectively. The variability in teachers' AI readiness suggests the need for structured professional development programs to equip educators with the necessary skills for AI-based teaching.

In a nutshell, this study was limited in several ways. Firstly, it focused on only four schools within Gauteng Province, meaning the sample may not represent experiences in rural or coastal regions. Secondly, the study examined only one programming concept (looping structures), which limits the applicability of findings to other coding topics such as conditionals or functions. Thirdly, only teacher perspectives were captured, excluding learners' voices.

These limitations restrict the generalisability of the findings. While the study offers insights into urban and township schools, further research is needed to confirm whether similar outcomes would emerge in rural or under-resourced provinces. Nevertheless, the study provides foundational evidence for designing AI integration strategies that can be adapted for broader use in South African schools.

6.3.Recommendations

Based on the findings of this study, several recommendations are proposed to enhance the effective integration of Artificial Intelligence (AI) in teaching looping structures within Gauteng Province schools. The recommendations aim to address the key challenges identified, including teacher training gaps, technological limitations, policy constraints, and the need for pedagogical innovation in AI-based learning.

To support effective AI integration in programming instruction, several actionable recommendations are proposed. Firstly, the Department of Basic Education should revise the Information Technology (IT) curriculum to formally include AI-supported programming tools—such as GitHub Copilot and ChatGPT—as optional teaching aids, particularly for topics like looping. Secondly, provincial education departments must implement mandatory workshops for IT teachers, focusing on how to effectively integrate these AI tools into code-based lessons. Such training should include practical demonstrations, ethical guidance, and examples drawn from local classroom experiences.

Thirdly, schools should be supported through policies that guarantee minimum AI-readiness, including stable internet connectivity, up-to-date hardware, and device-sharing strategies for resource-limited environments. Furthermore, the Department of Basic Education should launch a pilot programme to trial AI tools across diverse school contexts and evaluate their pedagogical value before scaling their use nationally. Lastly, there is a need to invest in the development of South African curriculum-aligned AI resources, including content in indigenous languages, to ensure both inclusivity and contextual relevance.

6.3.1 Enhancing Teacher Training and AI Literacy

A major challenge identified was the lack of teacher training in AI. To address this, the Department of Basic Education (DBE) should implement comprehensive AI training workshops that focus on both technical and pedagogical aspects of AI in education. These workshops should introduce teachers to AI-powered platforms, demonstrate how they can be used to support programming lessons, and provide hands-on experience in integrating AI tools into their teaching strategies. Additionally, schools should establish professional learning communities (PLCs) where teachers can collaborate, share best practices, and troubleshoot AI-related challenges. Encouraging peer learning through AI teaching networks will enhance teacher confidence and promote sustainable AI adoption in schools. As one of the interviewed teachers mentioned that they lack confidence when it comes to AI because they are not familiar with the platform.

6.3.2 Improving Technological Infrastructure

For AI to be effectively integrated into classrooms and assist in the teaching of looping structures, schools must have reliable digital infrastructure. The study found that poor internet connectivity and outdated computer systems hindered AI implementation in some schools. It is recommended that government and private stakeholders invest in upgrading school infrastructure, ensuring that all schools have stable internet access, adequate computing devices, and AI-supported software licenses.

Furthermore, schools should establish dedicated IT support teams to provide technical assistance to teachers and learners using AI tools. These support structures can help resolve technical issues quickly, ensuring that AI remains a seamless part of lesson delivery rather than an occasional supplement.

6.3.3 Policy and Curriculum Adjustments

The South African education system needs to formally integrate AI-based teaching methodologies into the national curriculum. The Department of Basic Education should develop guidelines and policies that support AI-driven learning while ensuring that teachers remain central to the teaching process. In addition, ethical concerns regarding AI use in education must be addressed. Policies should outline acceptable AI use, emphasizing academic integrity, data privacy, and responsible AI application in teaching. Clear ethical frameworks will help schools navigate AI implementation responsibly while maximizing its benefits.

6.3.4 Encouraging AI-Based Pedagogical Approaches

The study found that AI tools were often perceived as administrative aids rather than interactive learning facilitators. To change this perception, schools should promote AI-driven teaching strategies that enhance learner engagement. For example, incorporating gamified AI-based coding exercises can make programming more interactive and engaging for learners, and maybe understand better the concept of looping structures. AI tools should be used to provide real-time feedback, adaptive learning pathways, and personalized support, making programming concepts like looping structures more accessible and easier to grasp.

By implementing these recommendations, South African schools can overcome the barriers to AI adoption and create a more inclusive and effective AI-driven learning environment.

6.4 Conclusion

This study examined the integration of AI in teaching looping structures in Gauteng Province schools. The findings highlight that while AI tools like Mind Joy, ChatGPT, and GitHub have the potential to enhance programming education, their implementation is hindered by teacher training gaps, infrastructural limitations, and a lack of awareness about AI's pedagogical benefits. The study underscores the importance of a blended teaching approach, where AI complements traditional teaching methods rather than replacing them. Teachers remain essential in guiding learners, and AI should serve as a supporting tool to enhance engagement, personalization, and efficiency in programming lessons.

Addressing the challenges identified requires structured AI training programs, investment in digital infrastructure, curriculum reforms, and ethical AI policies. By implementing these measures, South African schools can ensure that AI is effectively utilized to improve computational thinking skills, enhance programming education. Future research should expand on these findings by examining AI's long-term impact on learner performance, exploring different AI teaching models, and identifying best practices for AI integration in programming curricula. Through continued innovation and policy-driven AI adoption, South African schools can harness the full potential of AI in education, fostering a generation of digitally proficient learners.

Reference List

Alam, A. (2022). Employing adaptive learning and intelligent tutoring robots for virtual classrooms and smart campuses: reforming education in the age of artificial intelligence. In Advanced computing and intelligent technologies: Proceedings of ICACIT 2022 (pp. 395-406). Singapore: Springer Nature Singapore.

Baker, R. S. J. d., & Siemens, G. (2014). Educational data mining and learning analytics. Handbook of educational psychology, 2, 507-524.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brown, P. A. (2008). A review of the literature on case study research. *Canadian Journal for New Scholars in Education/Revue canadienne des jeunes chercheures et chercheurs en education*, 1(1).

Bruff, D. (2022, December 20). Three things to know about AI tools and teaching.

Chen, X., Xie, H., Zou, D., & Hwang, G. J. (2020). Application and theory gaps during the rise of artificial intelligence in education. Computers and Education: Artificial Intelligence, 1, 100002.

Chronicle of Higher Education. https://www.chronicle.com/article/what-will-determine-ais-impact-on-college-teaching-5-signs-to-watch

Christou, P. A. (2023). How to use thematic analysis in qualitative research. Journal of Qualitative Research in Tourism, 1(aop), 1-17.

Felix, C. (2020). Should robots replace teachers? Exploring the ethical and pedagogical implications of AI in K-12 education. New York University, Steinhardt School of Culture, Education, and Human Development.

Ferdowsifard, K., Barke, S., Peleg, H., Lerner, S., & Polikarpova, N. (2021). LooPy: interactive program synthesis with control structures. Proceedings of the ACM on Programming Languages, 5(OOPSLA), 1-29.

Forstag, E. H., & Cuff, P. A. (Eds.). (2023, August 14). Artificial intelligence in health professions education: Proceedings of a workshop. National Academies Press.

Gagnon, Y. C. (2010). *The case study as research method: A practical handbook.* : PUQ.

Igwenagu, C. (2016). *Fundamentals of research methodology and data collection.* : LAP Lambert Academic Publishing.

Johnson, R., & Brown, K. (2021). The Multifaceted Nature of Research. *Journal of Inquiry*, 28(4), 567-580.

Jones, E., White, L., & Davis, R. (2019). Research Methodology: A Comprehensive Guide. *Academic Press*, .

Jonsson, A. (2021). ASSESSING DELPHI AS A PROGRAMMING LANGUAGE FOR BEGINNERS: A relative assessment of programming languages from a beginner's perspective.

Merriam, S. B. (2009). Case study research in education: A qualitative approach (Vol. 3). John Wiley & Sons.

Nassaji, H. (2015). Qualitative and descriptive research: Data type versus data analysis. *Language teaching research*, 19(2), 129-132.

Nayak, J. K., & Singh, P. (2021). Fundamentals of research methodology problems and prospects. *SSDN Publishers & Distributors*, .

Noar, S. M. (2006). A 10-year retrospective of research in health mass media campaigns: where do we go from here? *Journal of health communication*, 11(1), 21-42.

Okonkwo, C. W., & Ade-Ibijola, A. (2023). Synthesis of nested loop exercises for practice in introductory programming. Egyptian Informatics Journal, 24(2), 191-203.

Pervin, N., & Mokhtar, M. (2022). The interpretivist research paradigm: A subjective notion of a social context. International Journal of Academic Research in Progressive Education and Development, 11(2), 419-428.

Qian, Y., & Lehman, J. (2017). Students' misconceptions and other difficulties in introductory programming: A literature review. ACM Transactions on Computing Education (TOCE), 18(1), 1-24.

Robinson, M. (2020). Exploring the Unknown: The Essence of Research. *Curiosity Quarterly*, 14(1), 33-45.

Rowe, N. C. (1988). Artificial Intelligence through Prolog by Neil C. Rowe. Prentice-Hall.

Swidan, A., Hermans, F., & Smit, M. (2018, August). Programming misconceptions for school students. In Proceedings of the 2018 ACM Conference on International Computing Education Research (pp. 151-159).

Tenny, S., Brannan, J. M., & Brannan, G. D. (2017). Qualitative study.

WARFIELD, D. (2010). IS/IT RESEARCH: A RESEARCH METHODOLOGIES REVIEW. *Journal of theoretical & applied information technology*, 13.

Waters, R. C. (1979). A method for analyzing loop programs. IEEE Transactions on Software Engineering, (3), 237-247.

Yin, R. K. (2018). Case study research and application: Design and methods (Vol. 5). Sage publications.

Zhou, Y., Xiong, Y., & Jin, M. (2021). Less is more: Consumer education in a closed-loop supply chain with remanufacturing. Omega, 101, 102259.

Chen, X., Wang, Y., & Lin, J. (2022). AI in Education: A Review of Applications and Challenges in Teaching and Learning. Journal of Educational Technology, 39(3), 45-67.

Holmes, W., Bialik, M., & Fadel, C. (2021). Artificial Intelligence in Education: Promises and Implications for Teaching and Learning. Routledge.

Mishra, S., & Mehta, R. (2023). Bridging the Digital Divide: AI in Under-Resourced Schools. Computers & Education, 187, 104567.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–Where are the educators? International Journal of Educational Technology in Higher Education, 16(1), 39.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. International Journal of Qualitative Methods, 16(1), 1–13.

Appendices

Appendix: A – Turnitin Report

M.Ed Report-N.Khumalo 2263103-2.docx

ORIGINALITY REPORT

14%	4%	3%	11%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Witwatersrand Student Paper	12%
2	Iuliana Petronela Gârdan, Magdalena Beatrice Manu, Daniel Adrian Gârdan, Lucian Dragoș Leonard Negoiță et al. "Adopting AI in education: optimizing human resource management considering teacher perceptions", Frontiers in Education, 2025 Publication	1%
3	www.education.gov.za Internet Source	1%
4	Submitted to American InterContinental University Student Paper	1%
5	listens.online Internet Source	1%
6	mmcalumni.ca Internet Source	<1%
7	Keser, Ahmet Emre. "The Promise and Peril of AI Technology for Writing Instruction: An Exploratory Study on Stakeholder Attitudes Toward Using AI Tools in a University First-Year Writing Program", The University of Alabama, 2024 Publication	<1%
8	Abdullah Al Fraidan. "AI and Uncertain Motivation: Hidden allies that impact EFL	<1%

Appendix: B – Ethics Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | WSoE Wits School of Education

SCHOOL OF EDUCATION ETHICS COMMITTEE

CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: 2024ECE048M**

PROJECT TITLE

Leveraging the use of Artificial Intelligence in Teaching of looping structures in Programming languages: A case within South African Schools.

INVESTIGATOR	Nkosinathi Khumalo
SCHOOL/DEPARTMENT OF INVESTIGATOR	WSoE
DATE CONSIDERED	08 July 2024
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	Minimal Risk.
EXPIRY DATE	Date of submission of the Research Report
ISSUE DATE OF CERTIFICATE	23 August 2024
CHAIRPERSON	Dr. Lawan Abdulhamid

cc: Dr. Alton Dewa

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature **Date** 26 / Sep / 2024

27 St Andrews Road, Parktown, Johannesburg, 2193 | Pvt Bag 3, WITS, 2050 | T +27 11 717 3007 | www.wits.ac.za/education

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Appendix: C – GDE Approval Letter

GAUTENG PROVINCE

Department: Education

REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**10 July 2024**
Validity of Research Approval:	**08 February 2024– 30 September 2024** **2024/194**
Name of Researcher:	**Khumalo N**
Address of Researcher:	**220 Commissioner st**
	Johannesburg
Telephone Number:	**0825458178**
Email address:	**khumallon@gmail.com**
Research Topic:	**Leveraging the use of Artificial Intelligence in Teaching of looping structures in Programming languages: A case within South African Schools.**
Name of University:	**Wits**
Type of qualification	**Masters**
Number and type of schools:	**3 Secondary Schools**
District/s/HO	**Johannesburg East**

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.

10/07/2024

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:

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

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.*
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 the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools 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.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
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

....

Dr Gumani Mukatuni
DCES: Education Research and Knowledge Management

DATE: ...10/07/2024.........................

2

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

Appendix: D– Participation Information Sheet

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

PARTICIPANT INFORMATION LETTER FOR THE TEACHER

Good day,

My name is **Nkosinathi Khumalo**, I am a master's student at the University of the Witwatersrand, Johannesburg. My supervisor is **Dr Alton Dewa**. I am conducting a study on how teachers use artificial intelligence in teaching of looping structures. The study title is *"Leveraging the use of Artificial Intelligence in Teaching of looping structures in Programming languages: A case within Gauteng Province schools."*

As part of this research study, I humbly invite you to take part in an interview session. If you decide to take part, your participation in this research study will last for 30-45 minutes. I humbly again, ask to observe you while teaching looping structures in IT. The lesson observations will take place in your classroom after the teaching hours on agreed dates.

With your permission, I would like to record the interviews. Kindly note that your face will not be showed to protect your privacy. The data that will be retrieved during the lesson observations will be stored in for future secondary analysis in a google drive that will have an encryption/strong password that only me and my supervisor can access.

When I share the results of the research study, I will not include your name or anything else that could identify you such as the name of your school, or the district of your school. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used or passed on.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop being in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits, or rights you would normally have if you chose not to join. Taking part in the research study will not cost you anything. You will not be paid for being in this research study.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report. The report will be available on the university library website. If you would like to receive a summary of this report, I will be happy to send it to you.

If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

SIGNATURE

RESEARCHER: Nkosinathi Khumalo

EMAIL: 2263103@students.wits.ac.za.

CONTACT NUMBER: 082 545 8178

SUPERVISOR: Dr Alton Dewa

EMAIL: Alton.dewa@wits.ac.za

CONTACT NUMBER: 011 717 3337

Appendix: E– Consent Form

Consent Form

Title of project: "Leveraging the use of Artificial Intelligence in Teaching of Looping Structures in Programming Languages: A Case within South African Schools."

Name of researcher: Nkosinathi Khumalo

I, ……………………………………….., agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I can volunteer to take part in the study	YES	NO
I agree that the interview/focus group/other activity may be audio recorded	YES	NO
I agree that direct quotations from my interview may be used by the researcher in their research report.	YES	NO
I agree that my participation will remain anonymous (my name will not be used by the researcher in their research report.	YES	NO
I agree that other researchers may use the information I provide in my interview (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on.	YES	NO

Signature: ____________________________
Name of participant: ____________________________
Date: ____________________________

Signature: ____________________________
Name of the researcher: ____________________________
Date: ____________________________

Appendix: F– Interview Questions

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG 100 1922 2022

Interview Questions

Title of the Project: ***"Leveraging the Use of Artificial Intelligence in Teaching of Looping Structures in Programming Languages: A Case within South African Schools."***

Name of the Researcher: Nkosinathi Khumalo

1. **What methods do you use in teaching looping structures? What are the main challenges you face when teaching looping structures to your learners?**

2. **Have you ever used AI in your teaching? If yes, how have you integrated AI tools into your teaching of looping structures? Can you provide examples of specific AI tools or platforms you use?**
   If No, why?

3. **In your experience, how effective are AI tools in helping learners understand and apply looping structures compared to traditional teaching methods? [cognitive development]**

4. **How do you balance the use of AI tools with your traditional teaching methods to ensure you remain central to the learning process or align with the curriculum?**

5. **Have you noticed any changes in learner engagement or performance in learning looping structures since implementing AI tools? Please elaborate.**