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The Influence of Creative Coding, Robotics, and Artificial Intelligence on Educational Practices: Teachers' Perspectives

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ABSTRACT
Integrating Coding, Robotics, and Artificial Intelligence (AI) into educational practices represents a paradigm shift in how knowledge is imparted and acquired. This paper explored the multifaceted impact of these advanced technologies on contemporary education, highlighting their potential to enhance engagement, foster personalized learning experiences, and cultivate essential skills for the future. The study aimed to provide a comprehensive overview of how Coding, Robotics, and AI reshape the educational landscape by delving into specific applications, such as interactive learning environments and intelligent tutoring systems. Additionally, the discussion addressed the challenges and ethical considerations associated with these technological advancements, emphasizing the importance of a balanced approach that harnesses the benefits while addressing potential concerns. This paper is underpinned by the Theory of Situated Learning. A sample of five secondary schools in the OR Tambo Coastal District was selected for this study, with a focus on the experiences, behaviours, and social interactions of 15 teachers. Based on the study's interpretive paradigm, it was discovered that certain teachers were not aware of the importance of increasing their digital professional knowledge as we move toward the Fourth Industrial Revolution (4IR). In addition, infusing coding and robotics in educational practices required a shift to digital learning. The study recommends encouraging teachers to acquire new skills to avoid stagnation. Although not every teacher found updating their skills to be a motivating factor for continuing professional development, the study underscores the significance of continuous learning for personal growth and improvement.

Keywords: *Artificial intelligence, Coding, Robotics, Professional development, Technology, Landscape*

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INTRODUCTION
In recent years, the fusion of creative coding, robotics, and AI has sparked a new wave of technological innovation, transforming industries and redefining traditional concepts of human-machine interaction. This convergence represents an exciting frontier where artistry, engineering, and cognitive science intersect, offering limitless opportunities for exploration and progress. Creative coding, positioned at the intersection of programming and artistic expression, enables individuals to envision captivating digital experiences and dynamic visualizations. When combined with robotics, this creative medium surpasses conventional boundaries, giving life to mechanical entities and empowering them to interact with their

environment in unprecedented ways. Moreover, artificial intelligence serves as the catalyst, imparting these creations with cognitive abilities, allowing them to perceive, reason, and autonomously adapt. A rapidly expanding area, the application of AI and robots to the subject of education covers pedagogy and course design. Robot education may enhance students' practical abilities and interests via the integration of sophisticated technology, as indicated by Cao et al.[1] The intersection of creative coding, robotics, and AI has sparked a wave of innovation across diverse fields, ranging from interactive art installations to autonomous vehicles and intelligent systems. Despite significant advancements in leveraging these technologies individually, there is a noticeable lack of understanding regarding their combined impact and potential synergies. While successful examples of integration in specialized areas exist, a comprehensive exploration of the broader implications and opportunities presented by this convergence is absent in contemporary literature.

The existing gap in research stems from the absence of comprehensive studies that systematically analyze the interplay between creative coding, robotics, and AI, and its implications for technological innovation and human-machine interaction. While individual disciplines have been extensively studied, there is a scarcity of research exploring the synergistic effects and potential applications of their integration on a larger scale. Moreover, existing studies often concentrate on specific applications or technical aspects, neglecting the broader socio-cultural implications and potential ethical considerations of this convergence. The main objective of this study is to fill the identified gap by conducting a thorough analysis of the interaction between creative coding, robotics, and AI, and its implications for innovation and human-machine interaction. Specifically, the study aims to explore the current state of creative coding, robotics, and AI, including key technologies, trends, and applications, and to investigate potential synergies and intersections between these disciplines. It also intends to identify emerging opportunities for innovation and examine the socio-cultural, ethical, and economic implications of their convergence. Furthermore, the study seeks to propose frameworks and guidelines for the ethical development and deployment of integrated systems across various domains and to provide insights and recommendations for future research directions and practical applications in this field. By addressing these objectives, the study aims to contribute to a deeper understanding of the transformative potential of the convergence of creative coding, robotics, and AI, to inform policymakers, researchers, and practitioners about the opportunities and challenges inherent in integrating these technologies.

Ultimately, the study seeks to foster interdisciplinary collaboration and facilitate the responsible and ethical development of innovative solutions that leverage the creative potential of coding, robotics, and AI to enhance human well-being and societal progress. Additionally, the study emphasizes the wide-ranging impact of artificial intelligence and robots on the field of education, highlighting the potential to revolutionize and improve educational experiences through academic investigation and understanding of their uses and consequences. The impact of AI and robotics in education extends beyond just the classroom and into professional development. Programs such as the European Driving License for Robots and Intelligent Systems aim to standardize training and certification for educators and students in AI and robotics.[2] Additionally, the development of assessment indicators for measuring student learning in AI-based robot design provides valuable insights for engineering and technology educators. However, as these technologies continue to advance, ethical considerations must be addressed. The use of AI-enabled robots in fields like psychiatry and therapy raises questions about the ethical implications of delegating high-level therapeutic interventions to machines.[3] It is crucial to approach the integration of AI and robotics in education thoughtfully to ensure these technologies are used responsibly and ethically for the benefit of learners. Ultimately, the potential for AI and robotics to transform teaching and learning is significant, but we must navigate the ethical, social, and pedagogical implications to maximize their benefits.

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[1] Xiaole Cao et al., "Piezoelectric Nanogenerators Derived Self-powered Sensors for Multifunctional Applications and Artificial Intelligence," *Advanced Functional Materials* 31, no. 33 (2021): 2102983.

[2] Wen-Jye Shyr et al., "Development of Assessment Indicators for Measuring the Student Learning Effects of Artificial Intelligence-based Robot Design," *Computer Applications in Engineering Education* 27, no. 4 (2019): 863–68.

[3] Amelia Fiske, Peter Henningsen, and Alena Buyx, "Your Robot Therapist Will See You Now: Ethical Implications of Embodied Artificial Intelligence in Psychiatry, Psychology, and Psychotherapy," *Journal of Medical Internet Research* 21, no. 5 (2019): e13216.

LITERATURE REVIEW

The intersection of creative coding and robotics represents an exciting fusion of technology, art, and engineering. Creative coding deviates from traditional programming by prioritizing expression over functionality, focusing on aesthetics and creative processes rather than practical problem-solving. This approach finds applications in diverse fields such as art, design, music, and interactive installations. Artists and designers utilize creative coding to craft visual art, animations, and generative designs. Moreover, it is instrumental in developing interactive experiences, utilizing motion sensors, touch screens, and other input devices to engage the audience. By harnessing programming languages, creative coding enables the creation of innovative digital artworks and interactive installations, marking a field that continues to evolve rapidly, especially with the integration of machine learning, paving the way for more autonomous creative endeavours.[4]

Robotics is a multidisciplinary field encompassing robot design, construction, operation, and use. It integrates mechanical engineering, electrical engineering, computer science, and artificial intelligence. The physical construction of robots focuses on their structure, movement, and mechanics, requiring circuits, sensors, and actuators. Understanding and designing these electrical systems are critical for the functionality of robotics. Additionally, programming plays a crucial role in controlling the behaviour of robots, including coding for movement, perception, decision-making, and interaction. Furthermore, robotics involves designing, constructing, operating, and utilizing robots to perform tasks autonomously or with human intervention. In the realm of robotics in education, it has been demonstrated that it fosters creativity in students by involving them in the design of robots and engaging in creative programming processes.

The fusion of creative coding and robotics is especially evident in educational environments. Studies have highlighted the positive influence of teaching robotic coding on students' problem-solving abilities, computational thinking, and creativity.[5] Educational robotics enhances students' critical thinking and problem-solving skills, encourages teamwork, and facilitates real-world issue resolution using hands-on tools.[6] Furthermore, integrating robotics into education has contributed to developing students' creativity, technological acumen, and communication skills.[7] The intersection of creative coding and robotics gives rise to pioneering projects that combine art and engineering. Additionally, the link between technology, such as robotic coding education, and creativity in childhood has been emphasized, demonstrating a significant impact on children's creative thinking skills.[8] The confluence model of creativity has been used to explain how the design and coding of robots can positively impact students' creative output.[9] Additionally, the development of computational thinking through collaborative online learning in educational robotics has been linked to improving creative and working memory skills.[10] Introducing creative coding and robotics into educational environments enhances students' technical skills. It fosters creativity, problem-solving abilities, and collaborative work, preparing them for future careers that require innovative thinking and technological proficiency. Creative coding and robotics promote creativity, problem-solving, and interdisciplinary collaboration, pushing the boundaries of what technology and art can accomplish together.

AI is a branch of computer science that focuses on creating systems capable of performing tasks typically requiring human intelligence, such as learning, reasoning, problem-solving, perception, language understanding, and interaction. It is a transformative technology that involves developing intelligent

[4] John Danaher, "Robots, Law and the Retribution Gap," *Ethics and Information Technology* 18, no. 4 (2016): 299–309.
[5] Hatice Yildiz Durak, Fatma Gizem Karaoglan Yilmaz, and Ramazan Yilmaz, "Computational Thinking, Programming Self-Efficacy, Problem Solving and Experiences in the Programming Process Conducted with Robotic Activities," *Contemporary Educational Technology* 10, no. 2 (2019): 173–97.
[6] Ahmet Kesici, "The Effect of Digital Literacy on Creative Thinking Disposition: The Mediating Role of Lifelong Learning Disposition," *Journal of Learning and Teaching in Digital Age* 7, no. 2 (2022): 260–73.
[7] Akça Okan Yüksel, "Investigation of Pre-Service Science Teachers' Learning Experiences on Educational Robotics Applications," *Journal of Computer and Education Research* 10, no. 19 (2022): 50–72.
[8] Gubenko, Alla, Christiane Kirsch, Jan Nicola Smilek, Todd Lubart, and Claude Houssemand. "Educational robotics and robot creativity: An interdisciplinary dialogue." *Frontiers in Robotics and AI* 8 (2021): 662030.
[9] Mokonyane-Motha Matsie Magdeline, "Artificial Intelligence as a Tool to Reduce Graduates' Unemployment Needs," *International Journal of Social Science Research and Review* 6, no. 10 (2023): 130–43.
[10] Minrui Xu et al., "A Full Dive into Realizing the Edge-Enabled Metaverse: Visions, Enabling Technologies, and Challenges," *IEEE Communications Surveys & Tutorials* 25, no. 1 (2022): 656–700.

systems capable of handling tasks traditionally reliant on human intelligence. Integrating AI across various domains has led to significant advancements and process transformations. For instance, AI has played a crucial role in improving innovation processes, boosting productivity, and reshaping the nature of innovation across different sectors.[11] Moreover, AI has transformed digital content creation processes, transitioning from traditional methods to more efficient and innovative approaches.[12]

In computational creativity, which investigates the synergy between AI and creativity, there is a growing interest in utilizing machine learning techniques to enhance creative outputs.[13] Machine learning models have been deployed to analyze code duplication and identify code smells, which signal suboptimal design decisions in software development, enhancing the quality of generated code.[14] Moreover, in computational creativity research, machine learning has demonstrated potential in categorizing creativity, such as divergent thinking, using EEG data, suggesting broader potential for integrating machine learning in creativity studies.[15]

AI has also fostered creativity in various domains, including live coding and creating cultural and creative museum products.[16] By incorporating machine agents into live coding environments, coders can experiment with new coding patterns and pose novel questions, enhancing their creative processes. Furthermore, implementing computer vision and machine learning technologies has significantly propelled the development of cultural and creative products, underscoring the burgeoning role of AI in creative arenas. Integrating AI and machine learning techniques into creative processes has streamlined existing workflows and unlocked new opportunities for innovation and creativity across diverse fields. It has also been utilized to foster creativity in various domains, including live coding and creating cultural and creative museum products.[17] By incorporating machine agents into live coding environments, coders can experiment with new coding patterns and pose novel questions, enhancing their creative processes. Furthermore, implementing computer vision and machine learning technologies has significantly propelled the development of cultural and creative products, underscoring the burgeoning role of AI in creative arenas.[18] Integrating AI and machine learning techniques into creative processes has streamlined existing workflows and unlocked new opportunities for innovation and creativity across diverse fields.

Challenges encountered when incorporating Creative Coding, Robotics, and AI

There are several obstacles that educators face when trying to use cutting-edge teaching strategies like coding, robotics, and AI in the classroom. Teachers encounter a major obstacle due to a lack of knowledge and proper training about these technologies.[19] Integrating coding, robotics, and AI into classes may be problematic for many instructors since they may not have had enough professional development or have inadequate expertise in teaching approaches relating to these topics. Furthermore, primary school instructors are ill-prepared to use technological and robotic instruments since they are not adequately trained in these areas throughout their teacher education programs, although their students are expected to be competent in numerous disciplines.[20]

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[11] Iain M Cockburn, Rebecca Henderson, and Scott Stern, *The Impact of Artificial Intelligence on Innovation*, vol. 24449 (National bureau of economic research Cambridge, MA, USA, 2018).

[12] Meng Hao et al., "Efficient and Privacy-Enhanced Federated Learning for Industrial Artificial Intelligence," *IEEE Transactions on Industrial Informatics* 16, no. 10 (2019): 6532–42.

[13] Diogo Cardoso and Luís Ferreira, "Application of Predictive Maintenance Concepts Using Artificial Intelligence Tools," *Applied Sciences* 11, no. 1 (2020): 18.

[14] Miltiadis Allamanis, "The Adverse Effects of Code Duplication in Machine Learning Models of Code," in *Proceedings of the 2019 ACM SIGPLAN International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software*, 2019, 143–53; Dario Di Nucci et al., "Detecting Code Smells Using Machine Learning Techniques: Are We There Yet?," in *2018 Ieee 25th International Conference on Software Analysis, Evolution and Reengineering (Saner)* (IEEE, 2018), 612–21.

[15] Carl E Stevens Jr and Darya L Zabelina, "Classifying Creativity: Applying Machine Learning Techniques to Divergent Thinking EEG Data," *NeuroImage* 219 (2020): 116990.

[16] Hao Yu and Yunyun Guo, "Generative Artificial Intelligence Empowers Educational Reform: Current Status, Issues, and Prospects," in *Frontiers in Education*, vol. 8 (Frontiers Media SA, 2023), 1183162.

[17] Chia-Ling Chang et al., "From Digital Collection to Open Access: A Preliminary Study on the Use of Digital Models of Local Culture," *Education Sciences* 13, no. 2 (2023): 205.

[18] Yu Zhang and Mathias Funk, *Coding Art: The Four Steps to Creative Programming with the Processing Language* (Springer, 2021).

[19] Aisyah Mumary Songbatumis, "Challenges in Teaching English Faced by English Teachers at MTsN Taliwang, Indonesia," *Journal of Foreign Language Teaching and Learning* 2, no. 2 (2017): 54–67.

[20] Elena Jurado et al., "Social Steam Learning at an Early Age with Robotic Platforms: A Case Study in Four Schools in Spain," *Sensors* 20, no. 13 (2020): 3698.

Another key challenge for teachers is the struggle to incorporate coding, robotics, and AI due to practical constraints within the classroom environment.[21] Problems with physical space and large student body are common among educators and may make it difficult to use these technologies in lessons. Coding, robotics, and AI provide unique problems for educators who already confront the triple whammy of large class sizes, short class times, and inadequate classroom resources. Further complicating matters for educators trying to integrate coding, robots, and AI is the quick transition to online and distant learning, especially in the wake of pandemics like COVID-19.[22]

Teachers face more obstacles when trying to use technology in remote learning settings, including problems with student access to the internet and technology, a lack of clear guidelines from districts or schools, and the difficulty of engaging students and parents in virtual settings. Nevertheless, academics and practitioners alike should pay more attention to and have a better grasp of how AI might be integrated into enlightenment programs for young children.[23] Some believe that the development of AI necessitates a rethinking of educational practices and the way schools are structured so that students may make the most of the technology's potential in the classroom.[24]

AI may revolutionize the way we learn. A delicate balance between technical improvements and meticulous preparation is important to guarantee ethical concerns and successful implementation tactics.[25] Technical failures and challenges in technology control can make managing robotic classrooms difficult for teachers.[26] Educators have challenges when attempting to use educational robots due to factors such as the high expense of the devices, a lack of appropriate resources, and inadequate professional development opportunities.[27] Additionally, Jurado et al. noted that the absence of technological training in teacher education programs can leave elementary teachers without the necessary knowledge of technological and robotic tools, making the integration of robotics and AI into educational practices more difficult.[28] Furthermore, Alnaqbi & Yassin highlighted the challenge of maintaining human interaction between teachers and students in AI-based e-learning systems.[29] The importance of having skilled and capable teachers who can effectively navigate the advancements of AI, big data, and robotics in education is highlighted as a crucial component of the educational transformation.[30] Educators face challenges when trying to integrate robotics and AI into their lessons, including a lack of training, budgetary restrictions, outdated technology, and unclear job descriptions. A comprehensive strategy that incorporates strong support networks, training programs, and new pedagogical approaches is necessary to overcome these obstacles and enable the smooth incorporation of modern technologies into classroom instruction.

Teachers' Perspectives

Educators must have a good grasp of the pros and cons of using AI and robots in their teaching methods. Several studies have looked at this, and they have shown the pros and cons of using these technologies in the classroom. The literature emphasizes an important point: the possible advantages of using AI and robotics in classrooms. Personalized learning strategies, increased student engagement, and the development of critical thinking and problem-solving skills are just a few of the ways that modern

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[21] María José Seckel et al., "Primary School Teachers' Conceptions about the Use of Robotics in Mathematics," *Mathematics* 9, no. 24 (2021): 3186.
[22] Gregory M Francom, Sang Joon Lee, and Halle Pinkney, "Technologies, Challenges and Needs of K-12 Teachers in the Transition to Distance Learning during the COVID-19 Pandemic," *TechTrends* 65, no. 4 (2021): 589–601.
[23] Chenxing Wang et al., "An Empirical Evaluation of Technology Acceptance Model for Artificial Intelligence in E-Commerce," *Heliyon* 9, no. 8 (2023).
[24] Pravin R. Kshirsagar et al., "Human Intelligence Analysis through Perception of AI in Teaching and Learning," *Computational Intelligence and Neuroscience* 2022, no. 1 (2022): 9160727.
[25] Ido Roll and Ruth Wylie, "Evolution and Revolution in Artificial Intelligence in Education," *International Journal of Artificial Intelligence in Education* 26 (2016): 582–99.
[26] Sina Shahmoradi et al., "Evaluation of Teachers' Orchestration Tools Usage in Robotic Classrooms," *Education and Information Technologies* 29, no. 3 (2024): 3219–56.
[27] Morgane Chevalier, Fanny Riedo, and Francesco Mondada, "How Do Teachers Perceive Educational Robots in Formal Education? A Study Based on the Thymio Robot," *IEEE Robot Autom. Mag* 23, no. 2 (2016): 16–23.
[28] Jurado et al., "Social Steam Learning at an Early Age with Robotic Platforms: A Case Study in Four Schools in Spain."
[29] Alnaqbi, Ali Mohamed Ali, and Azlina Md Yassin. "Evaluation of success factors in adopting artificial intelligence in e-learning environment." *International journal of sustainable construction engineering and technology* 12, no. 3 (2021): 362-369.
[30] Sri Sukamta et al., "Peningkatan Kompetensi Teknik Visualisasi Ruang 3D Nyata Dengan Software Virtualtour Bagi Siswa Di SMKN 1 Kota Semarang," *Jurnal Pengabdian Kepada Masyarakat Nusantara* 4, no. 4 (2023): 4897–4904.

technology has expanded educational opportunities.[31] Furthermore, the introduction of AI into education has been hailed as a revolutionary change that offers unprecedented possibilities for revolutionizing conventional teaching approaches.[32] However, teachers are also aware of the many challenges that come with incorporating AI and robots into their lessons. Concerns about the ethical implications of AI on human rights and accountability for incidents using smart computers in the classroom have been raised by educators.[33] Additionally, operating robots near and with young learners presents a complex set of challenges that must be addressed.[34] To better understand teachers' perspectives on the integration of empathic robotic tutors in the classroom, studies have been conducted to identify the main roles that robots could play in education and to gather teachers' primary concerns regarding this type of technology.[35] These insights are valuable for ensuring that robots are utilized responsibly and effectively within daily school practices.

Professional Development Training

Educators who aspire to integrate robotics education into their teaching practices would benefit from teacher training programs that specifically prioritize this area of study.[36] To guarantee that teachers have the tools to captivate students and create a more productive learning environment, these programs should emphasize teaching robotics across several platforms. The effective integration of robotics education into other topics depends on instructors receiving pedagogical training in addition to technical training in AI and robotics. Teachers' willingness to adopt and use robotics education may be significantly impacted by their exposure to these technologies and the factors that contribute to it, as pointed out by Salas-Pilco.[37] As key stakeholders, teachers play an important role in how students interact with technology, incorporating robots into the classroom, and adapting to changes brought about by new technologies.[38] To fully realize the potential benefits of AI technology in education, it is important for training programs to address teachers' awareness of such concepts and their willingness to integrate them into their teaching practices.[39] By leveraging AI and robotics, educational institutions can create exciting and engaging learning experiences for students, promote learning efficiency, and foster interest in STEM discipline.[40] Ultimately, the integration of AI technology in education can lead to improved knowledge mastery and targeted training opportunities, thus expanding the scope of education.[41] With the necessary training and support, teachers can effectively use AI to enhance their teaching practices and improve student outcomes.

Robotics and artificial intelligence have become intertwined in various fields, showcasing significant advancements. While artificial general intelligence (AGI) remains a theoretical concept, the integration of artificial intelligence in robotics has led to the development of autonomous and intelligent robots.[42] The synergy between artificial intelligence and robotics has not only enhanced the capabilities of robots but has also paved the way for applications in diverse sectors such as healthcare, tourism, and education.[43] By highlighting the need for human specialists to collaborate with AI systems, the future of

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[31] Mehrnaz Fahimirad and Sedigheh Shakib Kotamjani, "A Review on Application of Artificial Intelligence in Teaching and Learning in Educational Contexts," *International Journal of Learning and Development* 8, no. 4 (2018): 106–18.
[32] Eman A Alasadi and Carlos R Baiz, "Generative AI in Education and Research: Opportunities, Concerns, and Solutions," *Journal of Chemical Education* 100, no. 8 (2023): 2965–71.
[33] Keping Yu et al., "Secure Artificial Intelligence of Things for Implicit Group Recommendations," *IEEE Internet of Things Journal* 9, no. 4 (2021): 2698–2707.
[34] Tony Belpaeme et al., "Social Robots for Education: A Review," *Science Robotics* 3, no. 21 (2018): eaat5954.
[35] Sofia Serholt et al., "Teachers' Views on the Use of Empathic Robotic Tutors in the Classroom," in *The 23rd IEEE International Symposium on Robot and Human Interactive Communication* (IEEE, 2014), 955–60.
[36] Aditya Prakash, Kashyap Chitta, and Andreas Geiger, "Multi-Modal Fusion Transformer for End-to-End Autonomous Driving," in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 2021, 7077–87.
[37] Sdenka Zobeida Salas-Pilco, "The Impact of AI and Robotics on Physical, Social-emotional and Intellectual Learning Outcomes: An Integrated Analytical Framework," *British Journal of Educational Technology* 51, no. 5 (2020): 1808–25.
[38] Jessy Ceha et al., "Can a Humorous Conversational Agent Enhance Learning Experience and Outcomes?," in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 2021, 1–14.
[39] Deren Ferikoğlu and Ergün Akgün, "An Investigation of Teachers' Artificial Intelligence Awareness: A Scale Development Study," *Malaysian Online Journal of Educational Technology* 10, no. 3 (2022): 215–31.
[40] Cao et al., "Piezoelectric Nanogenerators Derived Self-powered Sensors for Multifunctional Applications and Artificial Intelligence."
[41] Tan Kian Hua, "A Short Review on Machine Learning," *Authorea Preprints*, 2022.
[42] Ravi Raj and Andrzej Kos, "A Comprehensive Study of Mobile Robot: History, Developments, Applications, and Future Research Perspectives," *Applied Sciences* 12, no. 14 (2022): 6951.
[43] Abhishek Nagaraj, Esther Shears, and Mathijs de Vaan, "Improving Data Access Democratizes and Diversifies Science," *Proceedings of the National Academy of Sciences* 117, no. 38 (2020): 23490–98; Abrar Senhaji-Kacha, Jaime Esteban, and Meritxell Garcia-Quintanilla,

AI in robotics is likely to centre on AI-assisted robotic surgery instead of completely autonomous robots. In the context of the COVID-19 pandemic, for example, the use of AI and robots has shown potential in effectively handling catastrophes and other similar problems.[44] Facial recognition, chatbots, and language translation services are just a few examples of how the tourist and hospitality business has benefited from the proliferation of AI and robots in recent years. The convergence of AI, data analytics, and robotics is further shown by the creation of data-mining algorithm-based intelligent robot navigation systems. All things considered, the coming together of AI and robotics heralds a revolutionary age in which smart robots are supplementing human talents in all sorts of fields, with the promise of greater effectiveness, output, and capacity to solve problems.

THEORETICAL FRAMEWORK

This research is based on the Situated Learning Theory. A helpful paradigm for comprehending the incorporation of AI, robots, and coding into the curriculum is the Situated Learning Theory, put out by Lave and Wenger.[45] This theory emphasizes the importance of learning within authentic contexts and communities of practice, where learners engage in meaningful activities and develop skills through active participation.[46] The notion of Situated Learning emphasizes the importance of real-world problem-solving situations that students may encounter via hands-on learning experiences in the context of AI, robotics, and coding education. Situated learning as legitimate peripheral participation (LPP) is a theory put forward by Zheng and Guo that emphasizes the function of LPP in communities of practice. In these communities, beginners are guided by more experienced practitioners to progressively participate in increasingly difficult tasks and activities.[47] This idea proposes that students may learn more efficiently in the fields of AI, robotics, and coding when they work on real-world projects under the guidance of more seasoned instructors or mentors. Using the ideas put out by Situated Learning Theory, educators may create lessons that put students in real-world situations where they can apply AI to real-world problems, such as coding, robots, and challenges. Teachers may help students learn more about coding, robotics, and AI and improve their abilities in these areas by giving them chances to participate in authentic peripheral involvement and group problem-solving projects. Finally, by stressing the significance of active engagement within communities of practice and real, hands-on learning experiences, Situated Learning Theory provides a helpful framework for directing the incorporation of AI, robotics, and coding into the curriculum. Teachers may empower their students to build important skills in coding, robotics, and AI by employing the concepts of Situated Learning to create interesting and successful learning environments.

METHODOLOGY

A qualitative mode of inquiry with a case study as a research design was adopted in this study. Qualitative research is a methodological approach that allows researchers to explore and understand complex phenomena by delving into the meanings and interpretations individuals assign to them.[48] Unlike quantitative research, qualitative research is characterized by its less structured and more open-ended nature, providing flexibility in data collection and analysis.[49] This method can be employed independently to address specific research questions, integrated with quantitative approaches in mixed methods research, or embedded in clinical trials and complex intervention development.[50] In qualitative research, the researcher plays a crucial role in the study, actively engaging in data collection, interpretation, and

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"Considerations for Phage Therapy against Mycobacterium Abscessus," *Frontiers in Microbiology* 11 (2021): 609017; Rashmi Nedadur, Bo Wang, and Bobby Yanagawa, "The Cardiac Surgeon's Guide to Artificial Intelligence," *Current Opinion in Cardiology* 36, no. 5 (2021): 637–43..

[44] Alexios-Fotios A Mentis, Donghoon Lee, and Panos Roussos, "Applications of Artificial Intelligence− Machine Learning for Detection of Stress: A Critical Overview," *Molecular Psychiatry*, 2023, 1–13.

[45] J. Lave and E. Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge: Cambridge University Press, 1991).

[46] Zheng Chunxian, "Situated Learning as Legitimate Peripheral Participation," *Philosophy* 10, no. 10 (2020): 649–53.

[47] Tie Zheng and Guihang Guo, "Intention to Use a VR Learning System: A Moderated Mediation Model," in *Proceedings of the 14th International Conference on Education Technology and Computers*, 2022, 132–38.

[48] Egberto Ribeiro Turato, "Qualitative and Quantitative Methods in Health: Definitions, Differences and Research Subjects," *Revista de Saúde Pública* 39 (2005): 507–14.

[49] Deborah A Lekan, Susan K Collins, and Audai A Hayajneh, "Definitions of Frailty in Qualitative Research: A Qualitative Systematic Review," *Journal of Aging Research* 2021, no. 1 (2021): 6285058.

[50] Katherine Bristowe, Lucy Selman, and Fliss E M Murtagh, "Qualitative Research Methods in Renal Medicine: An Introduction," *Nephrology Dialysis Transplantation* 30, no. 9 (2015): 1424–31.

communication.[51] The process of qualitative research involves an iterative approach where new insights and distinctions are continually developed, leading to an enhanced understanding of the phenomenon under study.[52] Qualitative research methods often involve techniques such as interviewing and observation, allowing researchers to gather rich and in-depth data.[53] By employing systematic and reproducible methods, qualitative research contributes to generating nuanced insights that may not be captured through quantitative approaches.[54] Purposeful sampling was used to gather information from 15 teachers from five senior secondary schools in the OR Tambo Coastal District. Purposeful sampling is particularly suitable for qualitative evidence synthesis, as it allows researchers to systematically select diverse cases that offer valuable insights into the research topic.[55]

Ethical Considerations

It is crucial to prioritize ethical considerations when conducting any study, ensuring that research is conducted with integrity, respect, and fairness toward all involved parties. Researchers should be guided by fundamental ethical principles throughout the research process. Ethical guidelines play a pivotal role in evaluating the risk-benefit ratio of research, thus enabling the generalization of results to the broader population.[56] In this study, the researcher sought permission from the Eastern Cape Department of Education (ECDOE) to conduct research due to the involvement of teachers. Furthermore, the ethical considerations including informed consent forms were given to participants to allow them to exercise their right to be part of the research or not.[57] All participants were required to provide consent by signing informed consent forms. Participants used coded names, and the location of the interviews was kept confidential. Ensuring that individuals cannot be identified in recordings or print is crucial. Participants should feel confident that their information will be handled with utmost confidentiality. Protection from harm implies that the settings and participants should not be identifiable in print. The other way of protecting the participants' right to privacy was through the promise of confidentiality.

PRESENTATION OF FINDINGS

It became clear that there was a significant gender gap in the sample. Two men and thirteen ladies made up the total number of participants. To get things done, this part shares first-hand accounts from educators on how coding, robots, and AI have changed classroom dynamics. Regarding the sake of confidentiality, let's say that SAT is for the teachers at school A, SBT is for school B, SCT is for school C, SDT is for school D, and SET is for school E. Teachers' perspectives on coding, robotics, and AI; d in integrating these technologies into curricula; and opportunities for professional development in this area were the three overarching themes that emerged.

Views on Coding, Robotics, and Artificial Intelligence

The participants were also asked about their views on the integration of coding, robotics, and artificial intelligence. Regarding their concerns, a teacher said,

> *"Although coding and robotics need more training, I recognized the growing importance of technology in our society and the increasing demand for skills in coding, robotics, and AI in the workforce. "I also wanted to ensure that my students were well-prepared for the future and could develop valuable, in-demand skills."* Another teacher from another site stated, *"I am passionate about integrating coding, robotics, and AI into the classroom to enhance 21st-century skills, foster creativity and innovation, and prepare students for future success."*

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[51] Melinda M Leko, Bryan G Cook, and Lysandra Cook, "Qualitative Methods in Special Education Research," *Learning Disabilities Research & Practice* 36, no. 4 (2021): 278–86.
[52] Patrik Aspers and Ugo Corte, "What Is Qualitative in Qualitative Research," *Qualitative Sociology* 42 (2019): 139–60.
[53] Shazia Jamshed, "Qualitative Research Method-Interviewing and Observation," *Journal of Basic and Clinical Pharmacy* 5, no. 4 (2014): 87.
[54] Ehsanullah Tarin, "Qualitative Research and Clinical Methods," *Annals of King Edward Medical University* 23, no. 1 (2017).
[55] Charlotte Benoot, Karin Hannes, and Johan Bilsen, "The Use of Purposeful Sampling in a Qualitative Evidence Synthesis: A Worked Example on Sexual Adjustment to a Cancer Trajectory," *BMC Medical Research Methodology* 16 (2016): 1–12.
[56] Amit V Mahuli and Simpy A Mahuli, "Institutional Ethics Committee Regulations and Current Updates in India," *The Journal of Contemporary Dental Practice* 18, no. 8 (2017): 738–41.
[57] Nazmul Hasan et al., "Ethical Considerations in Research," *Journal of Nursing Research, Patient Safety and Practise (JNRPSP)* 1, no. 01 (2021): 1–4.

SDT2 responded by saying,

> *"Despite facing challenges related to diverse skill levels, limited resources, curriculum integration, and assessment, I am committed to overcoming these obstacles through collaboration, professional development, creativity, and support to create a supportive and engaging learning environment where students can develop valuable skills, knowledge, and competencies in coding, robotics, and AI."*

A participant from school C said,

> *"I believe that teaching coding in schools not only prepares students for future careers in technology but also fosters problem-solving skills, logical thinking, creativity, and perseverance."*

He continued to say,

> *"I am passionate about providing them with opportunities to explore and develop their coding skills."*

Another participant from school D said,

> *"I believed that coding, robotics, and AI could provide a platform for students to explore their creativity, experiment with new ideas, and develop innovative solutions to complex problems. I wanted to create a learning environment that encourages curiosity, exploration, and lifelong learning."*

Challenges faced by teachers when incorporating Coding, Robotics, and AI

Students may have varying levels of prior knowledge and experience in coding, robotics, and AI, making it difficult to meet the needs of all students in the classroom.Similarly, one participant responded by saying,

> *"Due to the limited access to computers, robotics kits, and other technology required for teaching coding, robotics, and AI can hinder my effective teaching."*

Another participant said,

> *"Maintaining students' interest and motivation in coding, robotics, and AI can be challenging, especially when they encounter difficulties or find the content too abstract or challenging."*

Another teacher expressed the view that,

> *"Developing appropriate and effective assessment methods to evaluate students' understanding and skills in coding, robotics, and AI can be challenging."* Another participant from another site said, *"Integrating coding, robotics, and AI into existing curriculum standards and finding sufficient time within the curriculum to effectively teach these subjects alongside other subjects can be challenging."*

The following questions regarding challenges they encounter when incorporating coding, robotics, and AI into the curriculum were posed to teachers: What challenges do you encounter when incorporating coding and robotics in your curriculum? Teachers' responses were nearly alike, one being that,

> *"The lack of resources constitutes a major challenge for teachers and learners as it brings difficulties when trying to do practical lessons due to lack of resources."* Another participant pointed out that, *"Teachers express concerns about the limited access to computers, robotics kits, and other technology required for teaching coding, robotics, and AI." When incorporating coding and robotics in my class, a lack of adequate materials is also said to be pervasive."*

A third participant said,

> *"The need for increased funding, grants, donations, and support from school administrators and policymakers to acquire the necessary technology and resources for effective instruction."* One of the participants stated, *"I face challenges in integrating coding, robotics, and AI into existing*

curriculum standards and finding sufficient time within the curriculum to effectively teach these subjects alongside other subjects."

In the same vein, some of the participants responded by saying,

"I found the difficult to develop appropriate and effective assessment methods to evaluate students' understanding and skills in coding, robotics, and AI."

In response to the question, a participant indicated that,

"Learners share what they have. Since there are insufficient resources and not enough funds to provide resources there is a big problem."

Professional Development Training

The following question was posed to participants: What professional development training have you received in coding, robotics, and artificial intelligence (AI), and how has it supported you in integrating these technologies into your classroom curriculum? Regarding the above question, participants explained,

"I participated in a few professional development training sessions on coding, robotics, and artificial intelligence (AI) that were organised by the Department of Basic Education last year."

Another participant from another site said,

"I have learned various coding concepts, pedagogical strategies, and classroom resources to create engaging and interactive coding lessons and projects."

SET1 stated,

"Despite the lack of training organised by the Department of Basic Education, I have been able to design and implement engaging and meaningful learning experiences, differentiate instruction to meet the diverse needs of my students, and foster creativity, innovation, and critical thinking through hands-on, project-based learning activities."

SAT 3 said,

"Although there were few pieces of training organised by the department it is difficult for me to incorporate coding, robotics, and AI into the curriculum because I lack a piece of knowledge."

One participant responded in this way,

"Kunzima kakhulu kuthi singootitshala ngoba ambalwa kakhulu amathuba oba sifundiswe Lisebe leMfundo."

It is difficult for us as teachers because there are few trainings organised by our department. Another teacher from another site expressed her concern about her experience of incorporating coding, robotics, and AI into the curriculum.

DISCUSSION OF FINDINGS

The findings of the study on the challenges faced by teachers when incorporating coding, robotics, and AI into the curriculum reveal several key obstacles. Teachers encounter difficulties related to their subject matter knowledge, particularly in areas like Pedagogical Content Knowledge (PCK), which can hinder their ability to effectively integrate these advanced topics into their teaching practices.[58] The literature also highlights challenges associated with implementing student-centred pedagogies, which are essential for teaching coding, robotics, and AI effectively.[59] One significant challenge is the struggle to incorporate robotics as a stand-alone subject due to the existing packed curriculum driven by standardized testing,

[58] Elizabeth A Davis and Joseph S Krajcik, "Designing Educative Curriculum Materials to Promote Teacher Learning," *Educational Researcher* 34, no. 3 (2005): 3–14.
[59] Leslie S Keiler, "Teachers' Roles and Identities in Student-Centered Classrooms," *International Journal of STEM Education* 5 (2018): 1–20.

making it challenging for teachers to introduce additional subjects.[60] Moreover, teachers face intrinsic challenges such as personal knowledge gaps, and extrinsic challenges like insufficient resources and a lack of professional development opportunities, which impede the successful implementation of coding, robotics, and AI in the curriculum.[61]

Teachers also encounter obstacles related to the changing educational landscape, including challenges in computational thinking integration, and navigating the complexities of curriculum changes. Additionally, the lack of training and understanding of the curriculum poses significant challenges for teachers when incorporating these advanced topics into their teaching practices.[62] Furthermore, challenges related to the interpretation of curriculum intent, alignment with pedagogical philosophies, and practical implementation of digital tools like robotics and AI are prevalent among teachers.

The complexity of understanding and translating curriculum specifications into effective teaching and learning practices presents a significant hurdle for educators.[63] Despite these challenges, some teachers welcome the integration of humanoid robots and coding into the curriculum to align with educational requirements and meet students' developmental needs.[64] However, the challenges identified underscore the need for targeted support, professional development, and resources to help teachers overcome obstacles and effectively integrate coding, robotics, and AI into the curriculum. The lack of professional development training for coding, robotics, and AI poses significant challenges for educators aiming to integrate these advanced technologies into educational settings. Research findings indicated that one of the main obstacles to the adoption of these technologies is the insufficient training and accessibility provided to teachers.[65] This lack of training hampers educators' ability to effectively incorporate coding, robotics, and AI into the curriculum and deliver high-quality instruction in these areas. Furthermore, the absence of formal education and professional development opportunities on AI and robotics contributes to feelings of inadequacy among educators in leading the implementation of these technologies in educational systems.[66] The gap in training and knowledge dissemination in these fields hinders educators from leveraging the full potential of coding, robotics, and AI to enhance student learning experiences and outcomes. Studies have highlighted that professional institutions and commercial companies are more active in offering AI training compared to academic institutes, which are limitedly involved in providing such educational opportunities.[67]

This disparity in training provision further exacerbates the challenge faced by educators seeking to enhance their competencies in coding, robotics, and AI. The lack of ongoing education and training for healthcare professionals to stay current with AI and robotic advancements is also a critical concern.[68] Continuous professional development is essential to ensure that educators and healthcare professionals are equipped with the necessary skills and knowledge to effectively integrate these technologies into their practice and adapt to the evolving landscape of AI and robotics. In conclusion, the findings underscore the urgent need for comprehensive and accessible professional development programs that focus on coding, robotics, and AI to support educators in overcoming the challenges associated with integrating these technologies into educational settings.

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[60] Yu-Hui Ching et al., “Elementary School Student Development of STEM Attitudes and Perceived Learning in a STEM Integrated Robotics Curriculum,” *TechTrends* 63 (2019): 590–601.
[61] Peter Vinnervik, “Implementing Programming in School Mathematics and Technology: Teachers’ Intrinsic and Extrinsic Challenges,” *International Journal of Technology and Design Education* 32, no. 1 (2022): 213–42.
[62] Jianhua Luo and Gift Muyunda, “Teachers’ Voice in Zambia: How to Make Them Involved in Curriculum Development,” *International Journal of Asian Education* 2, no. 3 (2021): 388–97.
[63] Louise Paatsch, Kirsten Hutchison, and Anne Cloonan, “Literature in the Australian English Curriculum: Victorian Primary School Teachers’ Practices, Challenges and Preparedness to Teach,” *Australian Journal of Teacher Education (Online)* 44, no. 3 (2019): 61–76.
[64] Helen Crompton and Diane Burke, “The Use of Mobile Learning in Higher Education: A Systematic Review,” *Computers & Education* 123 (2018): 53–64; Dominic Chalmers et al., “Beyond the Bubble: Will NFTs and Digital Proof of Ownership Empower Creative Industry Entrepreneurs?,” *Journal of Business Venturing Insights* 17 (2022): e00309.
[65] Belinda De Simone et al., “Knowledge, Attitude, and Practice of Artificial Intelligence in Emergency and Trauma Surgery, the ARIES Project: An International Web-Based Survey,” *World Journal of Emergency Surgery* 17, no. 1 (2022): 10.
[66] Sean J Barbour et al., “Evaluating a New International Risk-Prediction Tool in IgA Nephropathy,” *JAMA Internal Medicine* 179, no. 7 (2019): 942–52.
[67] Floor Schuur, Mohammad H Rezazade Mehrizi, and Erik Ranschaert, “Training Opportunities of Artificial Intelligence (AI) in Radiology: A Systematic Review,” *European Radiology* 31 (2021): 6021–29.
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RECOMMENDATIONS

If the Department of Basic Education (DBE) want teachers to be able to successfully incorporate robots, artificial intelligence, and coding into their classrooms, more suggestions will be needed to fill the gap in professional development training in these areas. Educators should be the primary target of DBE's new coding, robotics, and artificial intelligence training programs. Teachers' skills in implementing these technologies into their lessons should be improved by these programs. Blended learning delivery modalities, which mix online materials with in-person workshops, were also proposed as a way to provide educators with more versatile and engaging professional development possibilities. In addition, to provide teachers with a well-rounded grasp of AI, robotics, and coding, they should promote interdisciplinary training that incorporates statistics, health informatics, and computer science into course offerings. Online courses, seminars, and training materials on AI, robotics, and coding should be readily available to educators. To meet the unique demands of teachers in the domains of AI, robotics, and computer science (coding), they should encourage cooperation between academic institutions, professional groups, and business associates. Computer science, health informatics, and statistics may be combined in an interdisciplinary programme to provide teachers with a well-rounded knowledge of AI, robots, and coding. Teachers may be better equipped to handle the challenges of incorporating new technologies into their lessons if they are encouraged to take initiative, given chances for collaborative curriculum creation, and supported in their pursuit of ongoing professional development. To further improve teachers' self-assurance and efficacy in integrating AI, robots, and coding into their lessons, it is important to make materials easily accessible, encourage hands-on learning, and promote reflective practice. The integration of coding, robotics, and AI into schools should be fostered via professional development opportunities for teachers and reflective curriculum preparation. Online courses, seminars, and training materials on artificial intelligence, robotics, and coding should be readily available to educators from the DBE.

CONCLUSION

To sum up, there are many different obstacles that educators encounter while trying to learn about AI, robotics, and coding in the classroom. These problems need well-planned solutions. One major obstacle that educators have when trying to incorporate these new technologies into their classrooms is the absence of professional development training. To provide students with high-quality training in coding, robotics, and AI, educators often face challenges connected to their subject-matter expertise, pedagogical methods, and availability of resources. Personalized professional development programs for educators that target these specific areas are crucial for addressing these issues. Educators may better equip their students for the digital future and inspire creativity in STEM education by following these ideas and addressing the gaps in professional development training.

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