

# A Theoretical Framework for Interrogating the Integration of Artificial Intelligence in Education

Kudzayi Savious Tarisayi<sup>a</sup>

<sup>a</sup> Stellenbosch University, Western Cape South Africa, kudzayit@gmail.com, <https://orcid.org/0000-0003-0086-2420>

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## Abstract

*Artificial intelligence (AI) and machine learning have become increasingly important in modern society and are poised to play an increasingly prominent role in education. This paper seeks to provide a theoretical framework for interrogating the integration of AI in education spaces. The paper argues that the eventual response of educators to recent developments in artificial intelligence is eerily like the earlier cycles of integrating ICT in education and, decades earlier, calculators into mathematics instruction. Premised on the argument that there are similarities between the calculator revolution in mathematics education and the ICT revolution in education several decades ago and the current ongoing developments in artificial intelligence, this paper offers a theoretical lens. The theoretical lens is composed of the Technology-Organization-Environment (TOE) framework, Technology Acceptance Model, Technological Pedagogical Content Knowledge, Socio-technical system theory, and Diffusion of Innovation theory. The paper concludes that despite spatial differences between the ICT revolution and the artificial intelligence revolution, there are shared similarities warranting adoption of a similar theoretical lens. Furthermore, factors that were considered pivotal in the integration of ICT are still relevant to the revolution of artificial intelligence.*

**Keywords:** Artificial Intelligence; Calculators; Information Communication Technology; Theoretical Lens.

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## Introduction

Recent scholarship and media coverage have often narrowed the conversations on artificial intelligence to ChatGPT. Although “ChatGPT is a remarkable AI language model that has revolutionized the way we communicate with machines... It might be overshadowing other innovative AI tools that are equally impressive, if not more so,” as Sharma (2023) noted. Nitin Sharma points out in an article titled Say Goodbye to ChatGPT: Here Are New AI Tools That Will Blow Your Mind that there are many other AI tools that are not receiving as much attention as accorded ChatGPT, both in the media and in the academia. The author draws on Sharma (2023)’s view and focuses on artificial intelligence instead of what has become the prevailing norm of restricting conversations to ChatGPT. The pace at which artificial intelligence tools are being released each week warrants a more generalized approach to the discussion instead of specifically focusing on only one AI tool as in the case of ChatGPT. The paper seeks to provide a theoretical framework for interrogating the integration of artificial intelligence in education spaces. As a teacher educator, education space often includes both higher and tertiary education as well as schools where our students end up teaching. Therefore, this paper takes a generalized approach to education space to include both higher and tertiary education and schools. Additionally, it should also be noted that education spaces are relative and the integration of technology in the global south takes longer and plays a catch-up game. This paper starts by providing a background on the use of calculators and the integration of ICT in education. The next section briefly discusses artificial intelligence as well as presents similarities between ICT revolution (and introduction of calculators in mathematics education) and the artificial intelligence revolution. The author then presents the problem statement, which is followed by an analysis of the theoretical lens available to interrogate the integration of artificial intelligence.

## **1. Background on the introduction of calculators in education**

Calculators were first introduced in the 1960s and were used primarily in the fields of science, engineering, and business. As the technology improved, calculators became more affordable and more widely available, and their use spread to other fields, including education. In the 1970s, calculators were introduced in classrooms as a tool for teaching math. At first, they were used primarily in high school and college-level maths courses, but their use eventually spread to lower grade levels as well. However, the integration of calculators drew criticism from scholars who argued that calculators would make students lazy and hinder their ability to perform basic arithmetic. Counterarguments were also offered in support of the integration of calculators as they argued that they can be a useful tool for helping students understand complex mathematical concepts. Despite the controversy, calculators are now a common tool in maths classrooms at all levels, and many standardized tests allow or even require their use. They have also led to the development of more advanced calculators, such as graphing calculators, which allow students to visualize mathematical functions in new ways. Essentially, the author draws from this cycle of resistance and eventual acceptance of calculators in maths classroom to argue that it is only a matter of time before artificial intelligence gains its acceptance in education spaces.

In recent years, the integration of information and communication technologies (ICTs) in education has become increasingly popular. Tarisayi (2022, p. 126) notes “there is emerging consensus on the utility of information Communication Technology (ICT) in the classroom.” Incorporation of ICTs into education has revolutionized traditional teaching and learning methods. The use of information technology in education has transformed the way students and teachers learn. The main reason for integrating ICT into education is to improve the quality of education provided to students. ICT can improve education quality by providing access to a wide range of educational resources. CT provides students with a variety of multimedia resources such as videos, animations, and simulations that can help them better understand complex concepts. Furthermore, the use of ICT in education has made learning more interactive and collaborative. Students can participate in online discussions, collaborate on projects, and share information with others, which promotes teamwork and improves their learning experience. In addition, the integration of ICT into education enables students to learn at their own pace and according to their learning styles. This resulted in improved student outcomes, including higher academic achievement and better information storage. Resource-related challenges ranging from teacher competency and attitudes, shortage of computers, and lack of access to the latest software and internet have been noted in the global south. These challenges associated with the integration of ICT in education can be addressed through effective planning, implementation, and training. The benefits of ICT integration in education make it an essential component of modern education systems.

Technological innovations have been met with different reactions in different professions. The response of educators to recent developments in artificial intelligence is eerily similar to the earlier cycles of integrating ICT in education and, decades earlier, calculators into mathematics instruction. While it is common knowledge that a lot has changed over time in education spaces since calculators found their way into the mathematics classroom, reaction to innovation has not changed much theoretically. This paper leverages some of the theories previously utilized to study the integration of ICT in education to argue that the eventual response to artificial intelligence will be cyclic, repeating what has already been experienced. Artificial intelligence and machine learning have become increasingly important in modern society and are poised to play an increasingly prominent role in education. Education plays an important role in preparing learners for the real world. Bill Gates revealed in an interview with the CNBC that “the optimizations that AI can offer for reading and writing will make a huge impact in the health care and education spaces” (Goswani, 2023). As technology is increasingly embedded in our daily lives, there is an increasing need to align education with these changes in society. Education is the fundamental foundation of any society, and a strong education system is essential for the sustainable development of any nation.

Seven decades ago, the world, especially developed and Western countries, was still adapting to the use of calculators as a tool to improve students' mathematics skills (Manhibi, 2019; White, 2008). Banks (2011, p. 2) states that “some educators feared that students would not be able to retain their knowledge of simple arithmetic if they learnt to use a calculator before fully grasping basic mathematical concepts.” Essentially, the introduction of calculators into the mathematics classroom was met with reservations. Orton and Frobisher (2004, p. 10) argue that “The initial worry about calculators, which for some people has never gone away, is that children will not learn essential number skills if they are allowed to use calculators too soon. However, children meet calculators and computers in their world outside school, not least quite likely in their homes, and calculators and computers are ubiquitous in modern society, to such an extent that to ignore them at school would lead to the accusation that we were not preparing children for the real world.” Fundamentally, the author extends the same argument that was proffered justifying the introduction and use of calculators in mathematics more than half a century ago. If the education system prepares graduates for the real world, learners should be exposed to artificial intelligence in school and university. Artificial intelligence is part of the real world that the education system is supposed to be preparing learners for. Orton and Frobisher's quotation highlights a common concern about the use of technology in education, particularly in the context of artificial intelligence (AI). While some may worry that relying on AI for tasks such as grading or personalized learning may hinder students' development of essential skills, it is important to recognize that AI is already a ubiquitous part of modern society. However, decades later, Chamoso and

Caceres (2018, p. 1087) note that “It is thought-provoking that today computers and calculators are considered important tools for doing calculations and it seems that many jobs and occupations could not be carried out as they are now without them.” Calculators have become an everyday tool, and all phones come with a calculator that people can easily access. The author argues that a similar trend to the cycle of reaction to the use of calculators is occurring in the acceptance and use of artificial intelligence in the education space. Therefore, as we experience this same familiarity, it is essential to look to the past and apply some of the theories previously applied to this latest learning curve.

As in all revolutions, innovations are always met with skepticism and resistance. The incursion of artificial intelligence is no different; apocalyptic verdicts have already been expressed, and academics panicking about the implications of, for example, ChatGPT on assessments. The adoption of the calculator in the teaching and learning of mathematics was also met with similar skepticism and arguments that assessments were doomed. However, it is common knowledge that mathematics and mathematics assessment weathered the storm that came with the introduction of calculators and emerged stronger. Resultantly, this author argues that the higher education will wither the artificial intelligence storm and emerge stronger. While higher education as a ship will not be sunk by the artificial intelligence storm, some sailors will be lost at sea. All major players in the technology field have joined the artificial intelligence race, and therefore, it stands to reason that skepticism and resistance on the part of the academia render them irrelevant. The role of academics was important in the integration of ICT in higher education and will also be central in the use of artificial intelligence in higher education. Phiri (2016, p. 78) argues that “investing heavily in procuring computers and other ICT facilities would remain futile if the people who are supposed to use the said ICT tools are ignored ... computers and ICT facilities are useless in themselves if people who are supposed to use them are absent or do not appreciate such technologies ... teachers are a key component in the delivery of technological innovation in the classroom.” Academics should appreciate the capabilities that come with artificial intelligence in education spaces. The potential of artificial intelligence in the education space is immense, and with the right attitude, it can be harnessed to create more engaging and effective learning experiences. Embracing the AI revolution will help unlock new opportunities for higher education institutions and their students alike. For example, AI-driven platforms, such as chatbots, can be used to provide students with personalized guidance and support, while AI-driven virtual reality simulations can help students gain new insights into complex topics. Ultimately, with a commitment to innovation, artificial intelligence can help transform higher education for the better. Due to the confluence of the earlier reaction to the introduction of calculators and computers in the classroom and the current reaction to the incursion of artificial intelligence, this paper offers a theoretical lens for studying the current trend in artificial intelligence in general and ChatGPT in particular.

The author drawing from theories previously applied to the integration of calculators and computers in education proffers the argument that artificial intelligence is essentially a continuation, if not an extension of the integration of ICT in education and therefore should be treated as such. Some of the arguments related to ICT integration in the classroom still hold and are relevant to artificial intelligence incursion into higher education spaces. For example, Bilbao-Osorio and Dutta (cited in Tarisayi & Manhibi, 2017, p. 34) argues that “advances in the field of ICT have drastically changed teaching and learning because they can perform a variety of tasks that could not be easily performed before they emerged.” Fundamentally, with artificial intelligence such as ChatGPT and BING among others, the education space will be significantly changed as various tasks can be performed easily and faster. In addition to the benefits of exposing students to AI, the use of AI in education can also help make learning more personalized and efficient. AI-enabled systems can automatically customize learning content, track student progress, and provide feedback that is tailored to each individual student. This can help ensure that students are receiving the most relevant content for their learning style and level of instruction. Furthermore, AI can be used to automate feedback and evaluation processes, allowing educators to spend more time providing meaningful instruction. Ultimately, the use of AI in education has the potential to revolutionize how students learn, making it easier for them to acquire essential skills. Just like the “calculator revolution” teaching and learning of mathematics was drastically changed by the introduction and use of scientific calculators. Furthermore, the same argument can be extended to artificial intelligence and its ability to help facilitate and simplify certain tasks. For example, with ChatGPT, teachers and students have access to an AI-driven system that can assist in providing answers to questions or provide additional clarification on topics. Similarly, BING enables students to access a range of digital resources quickly and easily. Thus, artificial intelligence can provide students with opportunities for more effective and efficient learning and teaching. Furthermore, AI-driven systems can also help teachers in the assessment process by providing quick feedback on student submissions.

### *1.1. Problem statement*

The author utilizes four theories to unpack the following question: What is the potential impact of artificial intelligence in education and how does it compare to the integration of calculators and ICT in education? The four theories were selected based on their previous application to studies related to integration of calculators and ICT in education.

## **2. Theories and their relevance to the discourse on artificial intelligence integration to education spaces**

This section presents various theories and their relevance to the current artificial intelligence revolution. The author provides a brief background to each theory and shows how the theory can be used in the conversation on the integration of artificial intelligence into education spaces. The following theories are presented as theoretical lens to understanding the integration of artificial intelligence: Technology-Organization-Environment (TOE) framework, Technology Acceptance Model, Technological Pedagogical Content Knowledge, Socio-technical system theory, and Diffusion of Innovation theory.

### *2.1. Technology Acceptance Model*

The Technology Acceptance Model (TAM) is a theoretical framework developed by Fred Davis in 1986 to explain the factors that influence individuals' decisions to adopt or reject new technologies. The model posits that perceived usefulness and perceived ease of use are the key determinants of an individual's intention to use a technology, which in turn influences the actual use of the technology. According to the TAM, perceived usefulness refers to the extent to which a technology is perceived to improve job performance, while perceived ease of use refers to the degree to which the technology is perceived to be easy to use. These two factors, along with other external variables such as social influence, determine an individual's attitude toward using a technology, which ultimately influences their intention to use it. The TAM has been widely used and tested in various settings, including in the context of higher education. Previously, TAM has been applied in studies on the introduction of calculators in mathematics education as well as computer integration in education spaces. Drawing from the main tenets of TAM, it can be viewed as a useful lens in addressing the introduction of artificial intelligence in education spaces. Artificial intelligence such as chatbots (ChatGPT, ChatSonic, etc) requires testing in higher education, and therefore, TAM provides a lens for interrogating the findings to a certain extent. Chatbots are computer programs designed to simulate human conversation, and they can be used for a variety of purposes, including providing student support, answering questions, and offering personalized learning experiences. In the context of higher education, the TAM can be applied to understand students' acceptance of chatbots as a new technology. For example, students may perceive chatbots to be useful if they can provide timely and accurate information, help with academic tasks, and offer personalized recommendations. On the other hand, students may perceive chatbots as difficult to use if they require a high level of technological expertise or are not user-friendly. In addition to perceived usefulness and ease of use, social influence can also play a role in students' acceptance of chatbots. For example, if students perceive that their peers or instructors are using chatbots, they may be more likely to adopt them as well. Overall, the TAM can provide a useful framework for understanding and predicting students' acceptance of chatbots in higher education. By identifying the factors that influence students' attitudes and intentions toward using chatbots, educators can design more effective interventions to promote their adoption and enhance students' learning experiences.

### *2.2. Technological Pedagogical Content Knowledge*

Another theory that has been widely used in studies on the integration of technology in education spaces is Technological Pedagogical Content Knowledge. Technological Pedagogical Content Knowledge (TPACK) is a framework that was developed to explain how teachers can effectively integrate technology into their teaching practices. TPACK emphasizes the importance of considering the interaction between technology, pedagogy, and content knowledge and how these three elements can be integrated to support student learning. According to the TPACK framework, effective technology integration requires teachers to have a deep understanding of three knowledge domains: content knowledge, pedagogical knowledge, and technological knowledge. Additionally, within the TPACK framework, content knowledge refers to a teacher's understanding of the subject matter they are teaching, pedagogical knowledge refers to their knowledge of effective teaching strategies and approaches, and technological knowledge refers to their understanding of the technology tools and resources available to support learning. The TPACK framework emphasizes the importance of integrating these three knowledge domains, as each can support and enhance the others. For example, a teacher with strong content knowledge may be able to leverage technology tools to help students visualize abstract concepts and make them more concrete. Similarly, a teacher with strong pedagogical knowledge may be able to use technology tools to create engaging and interactive learning experiences that support student motivation and engagement. In the context of higher education, the TPACK framework can be used to guide the development of effective technology integration strategies for teaching and learning. For example, instructors may need to develop their technological knowledge to effectively use digital tools and resources in their teaching. They may also need to consider how technology can be used to support student engagement and motivation, or how it can be used to promote collaborative learning and problem-solving. By considering the interplay between content knowledge, pedagogical knowledge, and technological knowledge, instructors

can develop more effective technology integration strategies that are grounded in research and evidence-based practices. Hence, this paper argues that the integration of artificial intelligence in education spaces is depended on content knowledge, pedagogical knowledge, and technological knowledge. Additionally, by integrating artificial intelligence effectively into their teaching practices, instructors can enhance student learning outcomes and better prepare students for the technological demands of the workforce.

### *2.3. Diffusion of Innovation theory*

The Diffusion of Innovation theory is a framework developed by Everett Rogers in 1962 to explain how new ideas, products, or technologies spread through a social system. The theory posits that the adoption and diffusion of innovations are influenced by several factors, including the characteristics of the innovation, the communication channels through which it is spread, the adopter's perception of the innovation, and the adopter's social system. According to the Diffusion of Innovation theory, the adoption of a new innovation typically follows a bell curve, with innovators and early adopters at the beginning of the curve, followed by the early majority, late majority, and laggards. Innovators and early adopters are typically more receptive to new ideas and technologies, while the late majority and laggards are more skeptical and resistant to change. In the context of higher education, the Diffusion of Innovation theory can be applied to understand the acceptance of AI as a new technology. For example, innovators and early adopters in higher education may be more likely to use AI to enhance their teaching and learning practices. They may be attracted to the potential benefits of AI, such as the ability to provide personalized support to students, automate administrative tasks, and improve the efficiency of teaching and learning. However, the Diffusion of Innovation theory also suggests that the adoption of AI may be slower among the late majority and laggards. These groups may be more skeptical of the benefits of using AI or may perceive the technology as difficult to use or unnecessary. Additionally, the diffusion of AI may be influenced by communication channels and social systems within higher education institutions. For example, if there is strong support and endorsement of AI from institutional leaders and colleagues, this may facilitate its adoption and diffusion. In general, the diffusion theory of innovation provides a useful framework for understanding and predicting the acceptance of AI in higher education. By identifying the factors that influence the adoption and diffusion of AI, educators and administrators can develop more effective strategies to promote its use and integration into teaching and learning practices. Additionally, considering the attitudes and perceptions of different groups of adopters, educators can tailor their communication and marketing strategies to promote the benefits of AI to different audiences.

### *2.4. Technology-Organization-Environment (TOE) framework*

Another theory that could be applied to the adoption of AI in higher education is the Technology-Organization-Environment (TOE) framework. The TOE framework is a theory that describes how the adoption and implementation of new technologies are influenced by factors related to the technology itself, the organization that is adopting it, and the external environment in which the organization operates. According to the TOE framework, the adoption of AI would be influenced by three factors: technology, organization, and environment. According to the TOE framework, the characteristics of the AI technology itself are its ease of use, reliability, compatibility with existing systems, and perceived benefits and drawbacks. In addition, the characteristics of the higher education institution that is considering adopting AI are its size, structure, culture, resources, and existing technological infrastructure. Lastly, the external factors that may influence the adoption of AI are the competitive landscape, regulatory environment, and social and cultural factors. For example, the TOE framework suggests that the adoption of AI may be influenced by factors such as the availability of technical support and training for faculty and students, the alignment of AI with the institution's strategic goals and values, and the degree of competition and innovation within the higher education sector. By considering these factors, educators and administrators can develop more effective strategies for the adoption and implementation of AI in higher education and ensure that the technology is aligned with the needs and goals of the institution. The Technology-Organization-Environment (TOE) framework was developed in the 1990s by researchers Tornatzky and Fleischer. The framework was initially created to explain the adoption of new technologies in business organizations, but it has since been applied to other contexts, including the adoption of technology in education. The TOE framework builds on earlier theories, including the Diffusion of Innovation and the Contingency Theory, which suggest that the adoption and implementation of new technologies are influenced by a range of internal and external factors. The TOE framework expands on these theories by providing a more comprehensive and systematic approach to understanding the factors that influence the adoption and implementation of technology in organizations. The framework has been widely used in research on technology adoption and implementation and has been applied to a range of contexts, including healthcare, education, and government. It has also been adapted and modified over time to reflect changes in the technological landscape and to account for new factors that may influence technology adoption and implementation.

### *2.5. Socio-technical system theory*

The last theory that is relevant to the integration of artificial intelligence in education spaces is the sociotechnical system theory. Socio-technical system theory is a framework that emphasizes the interaction between social and technical factors in shaping organizational structures and processes. It suggests that successful adoption of new technologies depends on how well they are integrated into the social systems of an organization. The socio-technical system theory was developed in the 1950s and 1960s by a group of researchers at the Tavistock Institute of Human Relations in London, including Eric Trist, Fred Emery, and Joan Woodward. They were interested in understanding the complex interactions between technology, people, and the organizational structures in which they work. Since then, the socio-technical system theory has been widely applied in a variety of fields, including education, healthcare, and manufacturing. In the context of education, scholars such as Chris Bigum, Colin Lankshear, and Michele Knobel have used the socio-technical system theory to explore the impact of technology on teaching and learning and to develop strategies for integrating technology in a way that aligns with the goals and values of educational institutions. When applied to the integration of artificial intelligence in education, the socio-technical system theory highlights the importance of understanding the ways in which AI interacts with the existing social structures of educational institutions. This includes considering the attitudes and beliefs of educators and students toward AI, as well as the impact that AI may have on existing roles and responsibilities within the educational system. By using a socio-technical system approach, educators and policymakers can develop strategies for integrating AI in a way that aligns with the goals and values of the educational system. This may involve investing in professional development programs to ensure that educators have the skills and knowledge needed to effectively incorporate AI into their teaching practices, as well as developing policies and procedures that promote the ethical and responsible use of AI in education. Ultimately, the successful integration of AI in education will depend on how well it is integrated into the existing socio-technical system and the ways in which it enhances the quality of teaching and learning.

## **3. Conclusion**

In conclusion, integrating artificial intelligence (AI) into education demands a nuanced grasp of the complex interactions between technology, organizational factors, and external environments. This paper has highlighted parallels between the revolutions sparked by calculators in mathematics education, information and communication technologies (ICTs) across education decades ago, and current developments in AI. By applying a theoretical lens comprising the Technology-Organization-Environment framework, Technology Acceptance Model, socio-technical systems theory, Technological Pedagogical Content Knowledge, and Diffusion of Innovation theory, critical factors for successful AI integration in education are elucidated. While the ICT and AI revolutions differ spatially, their shared similarities warrant adopting a comparable theoretical approach. Despite distinctions, common threads persist—embracing new technologies catalyzes shifts in pedagogies, roles, and processes within educational institutions. Educators and policymakers must carefully navigate this terrain, learning from past technological integration experiences. A judicious application of theoretical insights can maximize AI's educational benefits while mitigating potential pitfalls.

Integrating AI is an iterative journey requiring continual reevaluation as impacts on teaching, learning, and the broader ecosystem emerge. Sustaining open collaboration between educators, policymakers, technologists, and communities is vital. By synergistically uniting theoretical understanding with pragmatic implementation strategies, the education sector can harness AI's transformative potential while preserving its fundamental values and vision for holistic student development.

## **4. Recommendations**

The theoretical lenses presented in this paper have significant implications for research and practice around the integration of AI in education settings. Empirical studies grounded in the Technology Acceptance Model (TAM) and Diffusion of Innovation theory should examine factors influencing perceived usefulness, ease of use, and the diffusion patterns of AI technologies among educators and students. This research can inform strategies to facilitate widespread adoption. Additionally, professional development initiatives for educators should draw upon the Technological Pedagogical Content Knowledge (TPACK) framework to build the necessary knowledge across content, pedagogy, and technology for effective AI integration while maintaining robust instructional practices. Finally, analyzing the introduction of AI tools through the lens of socio-technical systems theory can elucidate impacts on existing organizational structures, roles, and processes in educational institutions. This analysis is vital for developing implementation strategies that harmoniously align the technical capabilities of AI with the social systems and values inherent to schools and universities. By operationalizing these theoretical perspectives through targeted research,

professional development, and organizational analysis, the education sector can smoothly navigate the opportunities and challenges accompanying the rise of AI.

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