AJOTE
African Journal of Teacher Education
ISSN 1916-7822. A Journal of Spread Corporation

Volume 14 No. 1 2025 Pages 20-42

Teachers' preparedness for implementing the Educational Coding and Robotics curriculum in South Africa

William Zivanayi, Serah Ntombikayise Malinga
Nelson Mandela University, South Africa

Abstract

It is a significant step that the Department of Basic Education has taken to integrate educational coding and robotics into the mainstream school curricula in a world where technology is a normal element of everyday life. A deeper examination of the schools' and teachers' readiness to adopt this new curriculum is significant to improve learning and boost active teaching techniques. The article aimed to examine the teachers' preparedness, interests, knowledge, and self-confidence in implementing the newly introduced learning area – Educational coding and robotics in the mainstream school curriculum. This study was framed in the Unified Theory of Acceptance and Use of Technology. Using a systematic review approach, articles obtained from PubMed, Embase, Google Scholar, Scielo, Scopus, and ERIC were critically analyzed to identify descriptive themes and analytical themes. The review showed that the attitudes of South African teachers on ECR hinge on the availability of resources, pedagogical computer skills, teachers' technological beliefs, and the management team's influences on technology. DBE needs to work closely with the teachers' training institutions and pedagogical experts to meet the needs of teachers and learners regarding educational coding and robotics curriculum. Engagement with teachers may increase their knowledge, skills, attitudes, and values for them to have a meaningful contribution to the educational coding and robotics curriculum.

Keywords: Educational coding and robotics; preparedness; teaching and learning resources; technology

1.0 Introduction and background

The World Economic Forum estimated that 65% of children entering primary school in today's day and age will end up working in jobs that require technological advancement soon (Shaturaev 2022). As a result, a call to introduce a technological-related curriculum was made the world over (Shaturaev, 2022). In South Africa, the Department of Basic Education (DBE) took the hint and introduced educational coding and robotics (ECR) into the school curriculum for Grades R to 3 in 2021 and Grade 7 in 2023. A full-scale implementation for the other grades is in the pipeline for 2024 (CAPS123, 2023). However, several significant holes in the education system impede the success of this wonderful invention (ECR) in South Africa and the most pertinent ones are the lack of resources and manpower (Damons & Cherrington, 2020). Educational coding and robotics are completely a new ball in the field and therefore, a lot of teacher training, equipment, and infrastructure upgrading must be done (CAPS123, 2023). In this paper, we highlight the factors that influence teachers in embracing the newly introduced subject ECR into the main steam curriculum.

In his State of the Nation address, President Cyril Ramaphosa highlighted the need for the Department of Basic Education (DBE) to support teachers to acquire skills required today and, in the future, including new technological disciplines (educational robots, data analytics, and so on) (Insider Education, 2024). In his speech, he also reiterated the need to create a framework for these courses so that both learners and educators can build new abilities in a changing environment through the adoption and use of technology.

The president's call initiated the Department of Basic Education in partnership with several institutions to train teachers in computer skills and coding (Takavarasha et al., 2018), the number of teachers under training is not enough to allow a successful implementation of the educational robotics curriculum (Schina et al., 2021). To exacerbate the situation, the development in technology (ECR included) in South Africa is hampered by inequalities in class sizes, infrastructure, and facilities, as well as a shortage of competent teachers (Brundenius 2017; Hara et al., 2000; Takavarasha et al., 2018).

Several technological subjects were introduced in the South African school curriculum but have since been abandoned or have been left for the well-established schools to do. Confronting technology can reduce the impacts of inequality; but, if the challenges of harmonizing teacher thought on the use of technology fail, there is also a big danger that it would increase the existing economic and social inequities (Takavarasha et al., 2018).

Technology's potential to close the digital gap between students and teachers mostly hinges on teachers' access to and usage of it (Mashile, 2016). As a result, helping educators to become digitally literate might simultaneously increase educational access and quality while also giving educators the digital skills they need (Chetty et al., 2018; Lyons et al., 2019). Therefore, South Africa must be ready to take full advantage of the ever-expanding speed and scope of technological change while making sure that, particularly in the South African context, new or worsening inequality is avoided. The Department of Basic Education and curriculum developers may find valuable insights from the experiences and perspectives of South African teachers, which they may use to continue supporting the sustainability of ECR in schools.

2.0 Research questions

The study sought to utilize a critical interpretive review process to identify factors that influence teachers' perceptions of integrated educational robotics as a learning area or as a learning tool. using method.

The review was guided by the following questions:

(i) *What are the teachers' concerns regarding teaching educational coding and robotics (ECR) curriculum in public schools in South Africa?*

(ii) *What mitigations can be done to minimize the challenges faced by teachers in teaching educational robotics curriculum in public schools in South Africa?*

3.0 Literature review

3.1 What is educational robotics and coding?

According to Angel-Fernandez and Vincze (2018), educational robotics are robots that are specifically designed to be used in educational settings. These robots can take many different forms, from small programmable robots that learners can code themselves to larger robots that are designed to interact with learners in a more social way (Anwar et al., 2019). The importance of educational coding and robotics need not be overstressed as it is highlighted below:

"Coding and robotics education not only prepares learners for future job opportunities but also fosters essential skills such as problem-solving, critical thinking, and creativity. Learners gain practical experience in engineering and manufacturing by learning how to design and operate robots. These are critical skills in an increasingly technologically advanced society. Schools in South Africa are starting to realize the importance of teaching robotics and coding,

and they are adjusting to develop curricula that will provide students with the knowledge and abilities they need to thrive in the digital era." CAPS123, 2023).

Therefore, the goal of the coding and robotics curriculum is to help learners become problem solvers, critical thinkers, cooperative and creative workers, members of a digital and information-driven society, users of ICT and digital tools, and converters of these abilities into solutions for societal issues (Oyelere et al., 2018).

3.2 Rationale for adding ECR to the curriculum.

Educational robotics in South Africa has gained significant momentum in the past five years, playing a vital role in both formal and informal education settings. This growing field of educational robotics combines aspects of content and hands-on learning experiences using robots in the South African curriculum (Duncan et al., 2017; Mpungose, 2020), which is a necessity for the learner to gain content and practical experiences needed for the advancing technological society. Kourtis et al., (2021); Darmawansah et al., (2023); Gubenko et al., (2021); Yang et al., (2020) pointed out that it is only through educational robotics that creativity is fostered, problem-solving skills are enhanced, and passion for innovative learning is improved among learners. Educational robotics allow opportunities for innovation and entrepreneurship, contributing to the country's development in technology-related fields (Kourtis et al., 2021; Shipepe et al., 2022). As South Africa continues to invest in education and technology, the field of educational robotics is likely to play an increasingly important role in shaping the nation's future education and workforce (Fares et al., 2021).

Several studies, encompassing pilot projects on ECR at primary level have illustrated how robots and coding may enhance computational thinking, creativity, and teamwork (Muñoz-Repiso and Caballero-González, 2019; Alam, 2022; Psyrra et al., 2023, Tshidi & Dewa, 2024).Pilot studies conducted in the foundation phase (Grade R to 3) between 2021 and 2023 demonstrated that early exposure to robotics enhances learners' motivation and facilitates the connection between theoretical knowledge and practical application (Ragusa & Leung, 2023; Alam & Mohanty, 2024; Tshidi & Dewa, 2024).

3.3 Dissenting arguments against the introduction of ECR in South African schools

Some education stakeholders have voiced strong concerns regarding the practicality of introducing Educational Coding and Robotics (ECR) in South African schools. Major arguments are that the education system is still grappling with foundational challenges, such as overcrowded classrooms, poor infrastructure, and a shortage of basic learning materials

(CAPS123, 2023; Tshidi & Dewa, 2024). In many rural and township schools, there is limited or no access to electricity, internet connectivity, or functional computer labs. Introducing a highly technical subject like ECR in such contexts is seen as premature and potentially exclusionary (Prinsloo, 2024). Several scholars shared the same sentiments that ECR was hurriedly introduced in primary schools CAPS123, (2023), because many of these schools do not have access to computers or other technology required for coding and robotics education and the correct software (Fares et al., 2021). While the curriculum provides guidelines, there are not enough teachers trained in the subject matter to effectively interpret and utilize it for the benefit of the learners. Critics argue that the government should first focus on addressing these systemic inequalities before introducing advanced subjects that require technological resources most schools currently lack.

During the pilot study report of 2022, for the ECR at Foundation Phase, it was revealed that the implementation of ECR across Grades R–3 hinged not just on infrastructure and curriculum design but also on the training and support offered to teachers (Tshidi & Dewa, 2024). The same sentiments on inadequate technological infrastructure in many South African schools was echoed by Greyling (2023), where he stated that there are nearly 16000 schools lacking dedicated computer laboratories in South Africa and as a result this will create a big challenge for the ECR curriculum implementation. This infrastructural deficiency limits the hands-on learning component with digital tools integral to ECR. ECR provides learners with an engaging and dynamic learning environment by allowing them to assemble and programme robots thus creating an enjoyable learning experience (Prinsloo, 2024). The ramifications of this deficiency are far-reaching since the practical aspects of the subject may remain unrealised, hindering the development of technical skills necessary for navigating the digitally integrated world (Castro et al., 2018).

During the pilot study of ECR for the grade R to 3, Leavy et al., (2023) revealed that language and mathematical literacy skills are essential to learn coding (indeed for all future learning and problem solving) yet the average primary school child in our South Africa is not proficient in foundational skills. 78% of grade three learners cannot read for meaning in any language and cannot do basic mathematics. Therefore, the introduction of ECR will make difficult for schools to cope and the ECR will distract schools from basic foundational skills essential at the foundation phase.

This review article aims to contribute to the understanding of teachers' readiness to implement the newly introduced learning area (ECR) in the mainstream school curriculum by supplying information about teachers' concerns and expressed needs while negotiating ECR as new curriculum content. The review aims to generate factors valuable for the stakeholders for a better understanding of teachers' feelings about the newly introduced ECR in the school curriculum in the South African context.

4.0 Theoretical framework

This study was grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT) framework. According to Venkatesh (2022); Venkatesh et al., (2016); Williams et al., (2015), and Yee & Abdullah, (2021), the UTAUT framework examines four major dimensions as behavioural determinants that are: performance expectancy, effort expectancy, social variables, and enabling environments. According to the UTAUT, behavioural intention and supportive circumstances directly and favourably affect how much the teachers perceive the use of technology either as a learning tool or subject. The four behavioural dimensions variables are used for the prediction of the perceptions and intentions for adopting and adapting an introduced technology (Venkatesh, 2022; Venkatesh et al., 2003). The variables are moderated by four moderators which are gender, age, experience, and voluntariness.

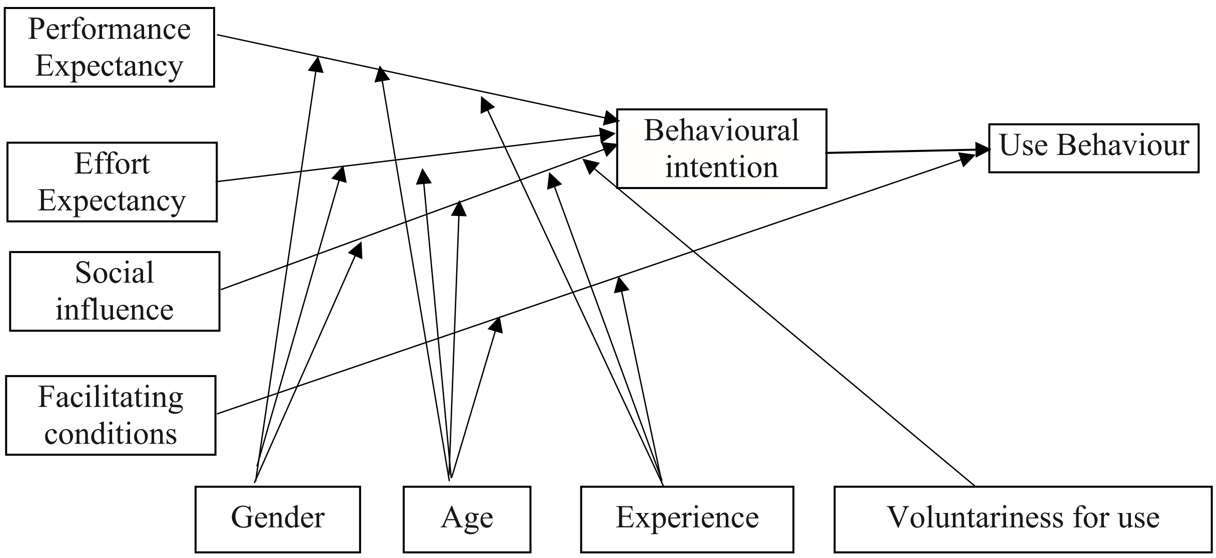

Figure 1: Unified theory of acceptance and use of technology framework (Adapted from Venkatesh et al., (2003)

The UTAUT model's variance explanation has been proven to be more robust (Venkatesh et al., 2003) because it reports a broad range of variables that affect how teachers and learners utilize technology. The framework has been applied globally and domestically in South Africa. The UTAUT framework will be used to assess the review's findings and provide suggestions for the stakeholders for sustaining ECR.

5.0 The Method

For this study, a qualitative technique was adopted, and data were derived from publications that used mixed, qualitative, and quantitative methodologies. A critical interpretive approach was utilized to compile the relevant data from the articles. In critical interpretive synthesis, the research issue is refined iteratively, literature is searched for and chosen from (using theoretical sampling), and codes and categories are defined and used in systematic analysis.

The databases that were searched online to get the data for this study were Google Scholar, Scielo, EBSCO Education Source, Scopus, and Springer. When combined, these databases provide access to a wide variety of education publications and indexed conference proceedings that contain details about the application of technology subjects like Educational Coding and Robotics (ECR), Information and Technology (ICT), Computer Application Technology (CAT), and so forth. The initial search included keywords such as technology, educational robotics in education, challenges in the implementation of technology and educational robotics curriculum, perceptions of teachers on educational robotics, robotics curriculum planning, and goals of educational robotics. This identified many articles focusing on these topics. The articles had to fulfill three requirements to be considered for inclusion in the review: (i) they had to be written in English; (ii) they had to investigate the use of technology or educational robotics and or computer application technology (mainly in South Africa); (iii) and (iv) they had been subjected to peer review(s). The articles were manually selected for inclusion and exclusion in two steps. Reading each article's title was the first step. Articles that seemed potentially relevant were then given more scrutiny by having their abstracts read. Finally, reading the whole article was the second step. Two reviewers who are also the authors of this paper separately carried out the search process. This process was done this way to minimize individual bias and guarantee the process's dependability.

6.0 Data analysis and synthesis

The final sample of articles underwent theme synthesis utilizing the three stages described in Thomas and Harden's thematic synthesis (Thomas & Harden, 2008). "Free codes" were created from the information obtained from the read articles. The “free codes” were then framed into categories to generate descriptive themes. The themes were eventually analyzed and used to respond to the research questions in this review study.

7.0 Results

The reviewed articles highlighted several aspects that affect teachers' opinions on new technology being included in the classroom. The descriptive themes that were found in these papers are summarized in Table 1. The descriptive themes were then used to generate four analytical themes: inadequate resources; preparedness and competence; teachers' beliefs; and management's influence and preferences.

Table 1: A summary of the descriptive themes and analytical themes identified from various read articles.

Descriptive themes	Analytic themes	References
Financial resources/funding (insufficient) Large class sizes Inconsistent power supply Poor internet connections Stealing of resources, equipment/safe and secure storerooms Lack of technical assistants/training of educators	Lack of resources	(Fares, 2021); (Kgarose et al., 2023); (Van der Bijl & Oosthuizen, 2019); (Chisango et al., 2020); (Makgato, 2003); (Ramnarain et al., 2023); (Chisango et al., 2020); (Torres & Giddie, 2020); (Mooketsi & Chigona, 2014);
Poor planning of the education department Lack of professional development programs Teachers’ technophobia/lack of confidence Age of teachers Perceptions that EdTech will add value and improve teaching and learning. No manpower Not understanding the benefits	Preparedness	(Ligami, 2022); (Trucano, 2014); (Azarfam & Jabbari, 2012); (Castillo-Canales et al., 2023; Shihab et al., 2023); (Sánchez-Prieto et al., 2019); (Singh, 2015); (Fares, 2021); (Kgarose et al., 2023); (Van der Bijl & Oosthuizen, 2019); (Chisango et al., 2020); (Makgato, 2003)

Pedagogical preference Poor subject content Principals' attitudes		
Teachers' beliefs and perceptions/teaching conditions/workload/preparation (prep) time. Perceptions that educational technology Easier access to knowledge	Teachers' beliefs	(Ramnarain et al., 2023); (Chisango et al., 2020); (Torres & Giddie, 2020); (Mooketsi & Chigona, 2014);
Leadership preferences No dedication to the use of information and communications technologies (ICT)/ School location/not knowledgeable about ICT School location/ state of community	Management influence and choices	(Ikuabe et al., 2020); (Wentzel et al., 2013); (Van der Bijl & Oosthuizen, 2019); (Nyembezi et al., 2016); (Msila, 2011)

Several characteristics, or key factors, associated with teachers' readiness and perceptions of a new technological introduction were highlighted in the reviewed articles. These key factors included the following: teachers' beliefs, practices, and reflections, teachers' knowledge, the response of teacher communities to reform, availability of resources, and management teams' influences (Balgopal, 2020; Mooketsi & Chigona, 2014; Msila, 2011; Mukeredzi, 2013; Ryder, 2015).

Gamage et al., (2021) and Uzorka et al., (2023) posit that the successful implementation of a new curriculum is based on the aspects that influence teachers' readiness for the change including personal, internal, and external factors. Internal factors include school culture, working practices, leadership, and support structures like teaching materials and other resources. External factors, on the other hand, have a systemic impact and address the flexibility or rigidity of new ideas in the curriculum and how they relate to or are affected by other reforms. Personal factors are related to teachers' subject knowledge, pedagogical skills, beliefs, and professional identity.

Among the problems cited by 70% of the examined articles as influencing teachers' attitudes and lack of readiness for the ECR are inadequate curriculum preparation, a lack of professional development, teachers' aversion to technology, pedagogical preferences, lack of educational coding and robotics pedagogy and school principals' and teachers' resistance to change (Anwar et al., 2019; Castillo-Canales et al., 2023; Gess-Newsome et al., 2019; Torres & Giddie, 2020). Teachers' attitudes regarding ECR are impacted by their inability to grasp and apply robotics skills (Chisango et al., 2020). Research also indicates that teachers may find teaching concepts too complex at times, which emphasizes the need for additional teacher preparation (Ramorola, 2013; Sadeck, 2016).

Educational coding and robotics being a novice subject in the South African context become a challenge to both teachers and learners. Learners need qualified and competent teachers as early as possible during the years of learning; they need to be taught by specialist teachers (Gess-Newsome et al., 2019). As research has shown, teacher quality is an important factor in determining gains in learners' achievement (Kind & Chan, 2019; Shim, 2023). Hence a need for skills and concepts training to be able to successfully integrate ECR in the mainstream curriculum. The Department of Basic Education (DBE) facilitated the short learning programs (SLP) in ECR under the University of Johannesburg to mitigate the shortage of ECR teachers. According to Schina et al. (2021), SLP failed to meet the demands of teachers since it did not provide them with the necessary pedagogical knowledge and abilities to integrate robots and educational coding into the curriculum. Teachers require greater training in situ (Guven & Kozcu Cakir, 2020) or exposure to technology-integrated teaching methodologies (Chisango et al., 2020). or training in situ (Guven & Kozcu Cakir, 2020). Without this deeper pedagogical knowledge, ECR is likely to experience a natural death (Ahmadaliev et al., 2022; D'Angelo, 2018).

According to Kind & Chan (2019), having a teaching qualification in ICT does not guarantee effective teaching - pedagogical skills are needed to impart the knowledge effectively. Since teachers are the primary agents of knowledge in any subject (educational robotics and coding included), the development of quality teachers is a primary condition for educational excellence, as noted by Huang et al. (2023) who posit that the quality of teaching and teachers has a significant impact on the quality of learning. This implies that quality teaching ECR is linked to teachers' understanding of the technological content knowledge and the ICT pedagogical pieces of knowledge, their beliefs about teaching and learning educational coding and robotics Fares, (2021); Vinnervik, (2020), and Vinnervik (2022), which ties in with the outcry in most South African schools Fares (2021) - where the experienced and qualified ECR teachers are few.

About 80% of the reviewed articles cited that the influences of the management contribute to the overall readiness to take any new technological advancement within the school curriculum. To effectively incorporate educational robots into curriculum delivery, management teams, particularly subject advisors, and school administrators, must possess the requisite skills and expertise (Msila, 2011; Nyembezi et al., 2016; Vinnervik, 2020). Principals' understanding of ECR affects their capacity to inspire teachers, even if they may not employ educational robotics in the classroom themselves (Van der Bijl & Oosthuizen, 2019).

8.0 Discussion

The UTAUT (Figure 1) suggests that four core constructs (performance expectancy; expectancy; social influence and facilitating conditions) are direct determinants of behavioural intention and ultimate behaviour of recipients and users of technology Venkatesh et al., (2003) and that these constructs are in turn moderated by gender, age, experience, and voluntariness of use (Vinnervik, 2020). The review is discussed based on the four constructs of the UTAUT framework. It is argued that by examining the presence of each of these constructs in a “real world” environment, researchers and practitioners will be able to assess an individual’s intention to use a specific technological innovation, thus allowing for the identification of the key influences on acceptance in any given context (Kelly et al., 2023).

According to Venkatesh et al. (2003), the UTAUT states that an individual's perception and usage of technology are significantly and directly impacted by the degree of support they perceive from technical and organizational infrastructure. When there are resource limitations, facilitating conditions are believed to be especially crucial (Venkatesh et al., 2003). The extent to which someone thinks that the current technological and organizational infrastructure can support the usage of technology is referred to as a "facilitating condition" (Abbad, 2021; Venkatesh et al., 2003). It is suggested that favourable settings have a major influence on user behaviour or actual usage (Ambarwati et al., 2020). Furthermore, it is claimed that behavioural intention has a major influence on user behaviour or real usage. According to (Ambarwati et al., 2020), enabling conditions include having enough resources and assistance available to people using technology. In South Africa, schools receive resource support for a few years before being asked to find their means to support themselves to continue with technological initiatives (Walton & Engelbrecht, 2022). When resources become limited, teachers’ zeal to teach also fades. Due to a lack of resources, insufficient help, delayed support, and inaccurate information in many South African schools, teachers may find it difficult to embrace ECR and/or use ECR as a teaching tool (Castillo-Canales et al., 2023; Shihab et al., 2023).

The level of convenience connected to using technology is known as Effort Expectancy (Venkatesh et al., 2003). This component includes the two areas of pedagogical compatibility and abilities, training, and competency as highlighted in this review. In South Africa, there are shortcomings in terms of teacher's skills, competence, and pedagogy for teaching ECR (Fares, 2021). When the South African government introduced SLP on ECR to teachers, very few of the teachers were able to join the program, leaving most of the teachers without the necessary skills to handle ECR in schools. Furthermore, the SLP content or curriculum was not aligned with the DBE's robotics curriculum (Fares, 2021). The SLP focused mainly on training teachers to utilize the ECR as a teaching tool rather than training them as a content subject. The department announced that the ECR was going to be introduced as a subject, yet the university(ies) selected to run the in-service training and short courses directed the teachers to use ECR as a teaching tool (Mooketsi & Chigona, 2014).

Educational coding and robotics being a novice subject becomes a challenge to both teachers and learners. Learners need qualified and competent teachers as early as possible during the years of learning; they need to be taught by specialist teachers (Gess-Newsome et al., 2019). As research has shown, teacher quality is an important factor in determining gains in learners' achievement (Kind & Chan, 2019; Shim, 2023). Factors that affect the quality of teachers in teaching technology in South African schools include class size, type of qualification, lack of pedagogy, and lack of support from stakeholders (Chisango et al., 2020); (Makgato, 2003); (Ramnarain et al., 2023). These factors lead to the development of attitudes towards any introduced technological advancement such as the ECR.

Pedagogical expertise and the development of competency and abilities in teaching ECR are closely associated (From, 2017). Teachers need to be exposed to the ECR to develop the necessary skills that will improve the way they handle learners in class for ECR and any other technological areas. Several studies show that to properly utilize technology, teachers must make a pedagogical change and establish new teaching techniques (Kgarose et al., 2023; Mukeredzi, 2013; Ryder, 2015). However, without the right training, teachers may lack the abilities essential to make this transition. A more productive learning environment may be created by integrating pedagogical approaches with technology, even in the face of possible opposition to change. Appropriate training can support this effort.

According to Kind & Chan (2019), having a teaching qualification in ICT does not guarantee effective teaching'. Since teachers are the primary agents in educational robotics and coding, the development of a quality teaching corps is a primary condition for educational excellence. This is noted by Huang et al (2023) who posit that educational excellence hinges upon the teachers' readiness to teach the subject. Quality teaching of the newly introduced subject, ECR depends on the teachers' understanding of the Technological content knowledge, and the ICT pedagogical knowledge, and their beliefs about teaching and learning educational coding and robotics (Fares, 2021; Vinnervik, 2020), which ties in with the outcry in most South African schools Fares, (2021) - where the experienced and qualified ECR teachers are few.

The current situation in the South African education system is that most teachers lack both formal and informal educational coding and robotics education (Vinnervik, 2020). Coetzee et al. (2021) share similar views, arguing that South African educators have little to no experience instructing learners on ECR. Most South African universities are yet to integrate ECR into relevant teacher training programs because they cannot train ECR teachers. The Department of Education is utilizing Computer Application and Technology (CAT) teachers for ECR. This complicates matters further because CAT teachers lack the depth in content to handle ECR. Vinnervik (2022) asserts that teachers who lack the necessary abilities frequently and without reflection use pre-made lesson plans. When using pre-made resources, learners typically lack inventive abilities that might compromise the subject's purpose, key content, and learning objectives. When it comes to ECR, innovative skills and higher-order thinking are crucial (Seechaliao, 2017).

Performance expectation, as defined by the UTAUT, is the extent to which an individual thinks that utilizing the technology would be advantageous (Venkatesh et al., 2003). This suggests that the teacher must be persuaded to use it by seeing the positive things the technology offers. Without adequate orientation of ECR in South Africa, there is likely to be a lower positive performance expectancy by the learners and teachers. The more the learners and teachers see the innovation being used, the greater their will to utilize depends on how much they think utilizing ECR will improve their performance on the job, their academic success, their ability to acquire digital skills, and other factors like reduced workloads.

Therefore, performance expectancy is found to be the most significant predictor of behavioural intentions (Venkatesh et al., 2003; Hart, 2023). Thus, performance expectancy among teachers must be improved to allow the adoption of ECR among the teachers. According to Venkatesh et al. (2003), performance expectation is the most important predictor of behavioural intentions. Therefore, to enable teachers to implement ECR, performance expectations must be improved to allow teachers to adopt the newly introduced subject, ECR.

The UTAUT model defines social influence as the idea that a person's behaviour is influenced by how they think others will perceive them because of their use of technology, as well as the influence people derive from the people they regularly interact with. (Venkatesh and Anuradha, 2019), Hart, (2023). The way a person thinks and determines whether a technological innovation is acceptable relies on social impact. This concept confirms that social influence plays a part in whether an invention is accepted or rejected (Akinnuwesi et al., 2022). When the ECR is required, social influence has a big impact. Individual teachers may choose to teach it in the required context out of compliance but not out of personal choice. This concept validates the function of societal cohesiveness in approving or disapproving an invention. For example, a favourable opinion of the ECR may arise from the degree to which stakeholders endorse an invention (Ikuabe et al., 2020; Wentzel et al., 2013).

Even though they may be able to overcome other ECR barriers, principals, and school management teams (SMT) may not be in favour of ECR adoption at their institution. Nevertheless, SMTs have a significant social influence because they can support the necessary technical support or skills training by providing manpower (Ikuabe et al., 2020).

This construct is not significant in voluntary contexts and has been found to become insignificant in non-voluntary contexts over time (Wentzel et al., 2013). Since ECR is at its infancy stage in South African schools, social influence plays an important role in gathering the support needed by the teachers to be prepared for ECR teaching.

9.0 Conclusion

The review study highlighted the factors which influence the teachers' perception of technological innovation. There were several factors identified that influence teachers' perception of technology-related subjects. Lack of resources, instructors' pedagogical readiness, teachers' views, and school administration teams all have an impact on technology decisions. One of the most crucial aspects that stakeholders should unquestionably consider before implementing any technology innovation in schools is teacher preparation. This makes it possible for teachers to have the appropriate pedagogy needed for instruction.

Faster information access and, a consistent power supply allows an effect use of technology and thus encourage teachers to adopt it in the classroom. The need to implement ECR in schools is confirmed by the President's recent declaration Ramaphosa (2019). This evaluation makes it clear that South African schools confront several obstacles that must be overcome to reap the benefits of implementing ECR, which has the potential to increase access to highquality instruction and lessen inequality. But if it's not done well, it can make the already-existing socioeconomic divide worse.

10.0 Acknowledgements

We would like to thank the Faculty of Education at Nelson Mandela University for the financial support they offered. The money went a long way to cover the expenses incurred during the writing of the article.

11.0 Data availability statement

The author confirms that all data generated or analyzed during this study are included in this published article reference list.

12.0 References

Abbad, M. M. (2021). Using the UTAUT model to understand students' usage of e-learning systems in developing countries. *Education and Information Technologies*, *26*(6), 7205-7224. https://doi.org/10.1007/s10639-021-10573-5

Alam, A. (2022). Educational robotics and computer programming in early childhood education: a conceptual framework for assessing elementary school students' computational thinking for designing powerful educational scenarios. 2022 International Conference on Smart Technologies and Systems for Next Generation Computing (ICSTSN), IEEE. DOI: 10.1109/ICSTSN53084.2022.9761354

Alam, A. and Mohanty A. (2024). "Integrated constructive robotics in education (ICRE) model: a paradigmatic framework for transformative learning in educational ecosystem." Cogent Education 11(1): 2324487. DOI:10.1080/2331186X.2024.2324487

Ahmadaliev, D., Metwally, A. H. S., Yousef, A. M. F., & Shuxratov, D. (2022). The Effects of Educational Robotics on STEM Students' Engagement and Reflective Thinking. 2022 IEEE Frontiers in Education Conference (FIE), DOI: 10.1109/FIE56618.2022.9962498

Akinnuwesi, B. A., Uzoka, F.-M. E., Fashoto, S. G., Mbunge, E., Odumabo, A., Amusa, O. O., Okpeku, M., & Owolabi, O. (2022). A modified UTAUT model for the acceptance and use of digital technology for tackling COVID-19. *Sustainable Operations and Computers*, *3*, 118-135. https://doi.org/10.1016/j.susoc.2021.12.001

Ambarwati, R., Harja, Y. D., & Thamrin, S. (2020). The role of facilitating conditions and user habits: a case of Indonesian online learning platform. *The Journal of Asian Finance, Economics and Business (JAFEB)*, *7*(10), 481-489. DOI: 10.13106/jafeb.2020.vol7.no10.481

Angel-Fernandez, J. M., & Vincze, M. (2018). Towards a definition of educational robotics. Austrian Robotics Workshop 2018,

Anwar, S., Bascou, N. A., Menekse, M., & Kardgar, A. (2019). A systematic review of studies on educational robotics. *Journal of Pre-College Engineering Education Research (J-PEER)*, *9*(2), 2. https://doi.org/10.7771/2157-9288.1223

Azarfam, A., & Jabbari, Y. (2012). Dealing with teachers' technophobia in the classroom. *Advances in Asian Social Science*, *2*(2), 452-455.

Balgopal, M. M. (2020). STEM teacher agency: A case study of initiating and implementing curricular reform. *Science Education*, *104*(4), 762-785. https://doi.org/10.1002/sce.21578

Brundenius, C. (2017). Challenges of rising inequalities and the quest for inclusive and sustainable development. *Universities, Inclusive Development and Social Innovation: An International Perspective*, 9-48. DOI: 10.1007/978-3-319-43700-2_2

CAPS123. (2023). https://caps123.co.za/coding-and-robotics-in-south-african-schools-the-importance-of-teaching-students-new-technology.

Castillo-Canales, D., Mejías, L., Roque, E., Valentini, A., & Ruebcke, J. (2023). Ed-Tech landscape and challenges in Latin America and the Caribbean. *Occasional Paper*(90).

Castro, E., et al. (2018). "Design and impact of a teacher training course, and attitude change concerning educational robotics." International Journal of Social Robotics 10: 669-685.DOI:10.1007/s12369-018-0475-6

Chetty, K., Aneja, U., Mishra, V., Gcora, N., & Josie, J. (2018). Bridging the digital divide in the G20: skills for the new age. *Economics*, *12*(1), 20180024. https://doi.org/10.5018/economics-ejournal.ja.2018-24

Chisango, G., Marongwe, N., Mtsi, N., & Matyedi, T. E. (2020). Teachers' perceptions of adopting information and communication technologies in teaching and learning at rural secondary schools in eastern cape, South Africa. *Africa Education Review*, *17*(2), 1-19. DOI: 10.1080/18146627.2018.1491317

Coetzee, C., Moodley, K., & Leshabane, K. M. R. (2021). *Understanding the effect of Robotics as an intervention strategy in a Technical Sciences class* University of Pretoria].

D'Angelo, C. (2018). The impact of technology: Student engagement and success. *Technology and the Curriculum: Summer 2018*.

Damons, B., & Cherrington, A. M. (2020). Reimagining community schools as beacons of hope and possibility in the South African context. *Education as Change*, *24*(1), 1-27. http://dx.doi.org/10.25159/1947-9417/4699

Darmawansah, D., Hwang, G.-J., Chen, M.-R. A., & Liang, J.-C. (2023). Trends and research foci of robotics-based STEM education: a systematic review from diverse angles based on the technology-based learning model. *International Journal of STEM Education*, *10*(1), 1-24. DOI: 10.1186/s40594-023-00400-3

Duncan, C., Bell, T., & Atlas, J. (2017). What do the teachers think? Introducing computational thinking in the primary school curriculum. Proceedings of the Nineteenth Australasian Computing Education Conference. https://doi.org/10.1145/3013499.3013506

Fares, K., Brian Fowler, B., Vegas, E. (2021). How South Africa implemented its computer science education program. In Brookings (Ed.), *Center for Universal Education* (1 ed., pp. 12). Brookings Institution: Brookings Institution.

From, J. (2017). Pedagogical Digital Competence--Between Values, Knowledge, and Skills. *Higher Education Studies*, *7*(2), 43-50. http://doi.org/10.5539/hes.v7n2p43

Gamage, K., Dehideniya, D., & Ekanayake, S. (2021). The Role of Personal Values in Learning Approaches and Student Achievements. Behavioral Sciences, 11 (7), 102. In. doi: 10.3390/bs11070102

Gess-Newsome, J., Taylor, J. A., Carlson, J., Gardner, A. L., Wilson, C. D., & Stuhlsatz, M. A. (2019). Teacher pedagogical content knowledge, practice, and student achievement. *International Journal of Science Education*, *41*(7), 944-963. DOI: 10.1080/09500693.2016.1265158

Greyling, J. (2023). "Coding unplugged—a guide to introducing coding and robotics to South African schools." Transforming Entrepreneurship Education 155. DOI:10.1007/978-3-031-11578-3_9

Gubenko, A., Kirsch, C., Smilek, J. N., Lubart, T., & Houssemand, C. (2021). Educational robotics and robot creativity: An interdisciplinary dialogue. *Frontiers in Robotics and AI*, *8*, 662030. https://doi.org/10.3389/frobt.2021.662030

Guven, G., & Kozcu Cakir, N. (2020). Investigation of the Opinions of Teachers Who Received In-Service Training for Arduino-Assisted Robotic Coding Applications. *Educational Policy Analysis and Strategic Research*, *15*(1), 253-274. DOI: 10.29329/epasr.2020.236.14

Hara, N., Bonk, C. J., & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional science*, *28*, 115-152. DOI: 10.1023/A:1003764722829

Hart, S. A. (2023). Identifying the factors impacting the uptake of educational technology in South African schools: A systematic review. *South African Journal of Education*, *43*(1).https://doi.org/10.15700/saje.v43n1a2174

https://insideeducation.co.za/ramaphosa-delivers-keynote-address-at-the-dbes-basic-education-sector-lekgotla-in-boksburg/Newspaper; Saturday, March 16, 2024

Huang, J., Sang, G., & He, W. (2023). Motivation to teach and preparedness for teaching among preservice teachers in China: The effect of conscientiousness and constructivist teaching beliefs. *Frontiers in Psychology*, *14*, 1116321. https://doi.org/10.3389/fpsyg.2023.1116321

Ikuabe, M., Aghimien, D., Aigbavboa, C., & Oke, A. (2020). Exploring the adoption of digital technology at the different phases of construction projects in South Africa. Proceedings of the International Conference on Industrial Engineering and Operations Management,

Kelly, S., Kaye, S.-A., & Oviedo-Trespalacios, O. (2023). What factors contribute to the acceptance of artificial intelligence? A systematic review. *Telematics and Informatics*, *77*, 101925. https://doi.org/10.1016/j.tele.2022.101925

Kgarose, M. F., Makhubela, D. K., & Setaise, L. C. (2023). Is Load Shedding Another Pandemic, Post COVID-19 at Institutions of Higher Learning in South Africa? *Perspectives of Law and Public Administration*, *12*(3), 447-456.

Kind, V., & Chan, K. K. (2019). Resolving the amalgam: connecting pedagogical content knowledge, content knowledge, and pedagogical knowledge. *International Journal of Science Education*, *41*(7), 964-978.https://doi.org/10.1080/09500693.2019.1584931

Kourtis, S., Xenakis, A., Kalovrektis, K., Plageras, A., & Chalvantzi, I. (2021). An Exploratory Teaching Proposal of Greek History Independence Events based on STEAM Epistemology, Educational Robotics, and Smart Learning Technologies. *Proceedings of the 2021 European Symposium on Software Engineering*,

DOI: 10.1145/3501774.3501792

Ligami, C. (2022). Poor planning for online learning created disparities. *University World News*.

Leavy, A., et al. (2023). "The prevalence and use of emerging technologies in STEAM education: A systematic review of the literature." Journal of Computer Assisted Learning **39**(4): 1061-1082.

Lyons, A., Zucchetti, A., Kass-Hanna, J., & Cobo, C. (2019). Bridging the gap between digital skills and employability for vulnerable populations. https://www.researchgate.net/publication/332013345

Makgato, M. (2003). *The development of a curriculum for technology teacher education and training: A critical analysis* Citeseer. URI:http://hdl.handle.net/10500/1082

Mangina, E., et al. (2023). "Robotics in the context of primary and preschool education: A scoping review." IEEE Transactions on Learning Technologies **17**: 342-363. DOI: 10.1109/TLT.2023.3266631

Mashile, T. Z. (2016). *Technology integration and the digital divide: understanding factors that impact on educators' ability to integrate technology in South African classrooms*. University of Pretoria (South Africa).

Mooketsi, B. E., & Chigona, W. (2014). Different shades of success: Educator perceptions of government strategy on E-Education in South Africa. *The Electronic Journal of Information Systems in Developing Countries*, *64*(1), 1-15. https://doi.org/10.1002/j.1681-4835.2014.tb00461.x

Mpungose, C. B. (2020). Student teachers' knowledge in the era of the Fourth Industrial Revolution. *Education and Information Technologies*, *25*(6), 5149-5165. https://doi.org/10.1007/s10639-020-10212-5

Msila, V. (2011). Changing and leading school culture: The school principal's role in the implementation and adoption of information technology. *International Journal of Technology, Knowledge and Society*, *7*(2), 119.

Mukeredzi, T. G. (2013). Professional Development Through Teacher Roles: Conceptions of Professionally Unqualified Teachers in Rural South Africa and Zimbabwe. *Journal of research in rural education*, *28*(11).

Muñoz-Repiso, A. G.-V. and Y.-A. Caballero-González (2019). "Robotics to develop computational thinking in early Childhood Education." Comunicar: Media Education Research Journal 27(59): 63-72. DOI:10.3916/C59-2019-06

Nyembezi, N., Cishe, N., & Mantlana, D. (2016). Teachers’ adoption of information and communication technology in foundation phase teaching: a study of selected schools in the Eastern Cape in South Africa. *International Journal of Educational Sciences*, *12*(1), 57-65. https://doi.org/10.1080/09751122.2016.11890413

Oyelere, S. S., Suhonen, J., Wajiga, G. M., & Sutinen, E. (2018). Design, development, and evaluation of a mobile learning application for computing education. *Education and Information Technologies*, *23*, 467-495. DOI 10.1007/s10639-017-9613-2

Prinsloo, L. (2024). Coding and robotics for the young child. a developing country's perspective. EDULEARN24 Proceedings, IATED. doi: 10.21125/edulearn.2024.2358

Ragusa, G. and Leung, L, (2023). "The Impact of Early Robotics Education on Students’ Understanding of Coding, Robotics Design, and Interest in Computing Careers." Sensors **23**(23): 9335. https://doi.org/10.3390/s23239335

Ramaphosa, C. (2019). State of the Nation Address 2019. *Cape Town*.

Ramnarain, U., Ncube, R., & Teo, T. (2023). South African Life Sciences teachers’ pedagogical beliefs and their influence on information communication and technology integration. *Frontiers in Education (Lausanne)*, *8*. https://doi.org/10.3389/feduc.2023.1217826

Ramorola, M. Z. (2013). The challenge of effective technology integration into teaching and learning. *Africa Education Review*, *10*(4), 654-670. https://doi.org/10.1080/18146627.2013.853559

Ryder, J. (2015). Being professional: accountability and authority in teachers’ responses to science curriculum reform. *Studies in Science Education*, *51*(1), 87-120. ttps://doi.org/10.1080/03057267.2014.1001629

Sadeck, O. G. (2016). *An exploration of e-learning practices of teachers at selected schools in the Western Cape* Cape Peninsula University of Technology. https://etd.cput.ac.za › handle

Sánchez-Prieto, J. C., Huang, F., Olmos-Migueláñez, S., García-Peñalvo, F. J., & Teo, T. (2019). Exploring the unknown: The effect of resistance to change and attachment on mobile adoption among secondary pre-service teachers. *British Journal of Educational Technology*, *50*(5), 2433-2449. https://doi.org/10.1111/bjet.12822

Schina, D., Esteve-González, V., & Usart, M. (2021). An overview of teacher training programs in educational robotics: Characteristics, best practices, and recommendations. *Education and Information Technologies*, *26*(3), 2831-2852. https://doi.org/10.1007/s10639-020-10377-z

Seechaliao, T. (2017). Instructional strategies to support creativity and innovation in education. *Journal of education and learning*, *6*(4), 201-208. doi:10.5539/jel.v6n4p201

Shihab, S. R., Sultana, N., Samad, A., & Hamza, M. (2023). Educational Technology in Teaching Community: Reviewing the Dimension of Integrating Ed-Tech Tools and Ideas in Classrooms. *Eduvest-Journal of Universal Studies*, *3*(6), 1028-1039. DOI: 10.59188/eduvest.v3i6.835

Shim, S. W. (2023). Elementary preservice teachers ‘competence in planning and implementing empathic design in cross-cultural stem education Purdue University Graduate School.

Shipepe, A., Uwu-Khaeb, L., De Villiers, C., Jormanainen, I., & Sutinen, E. (2022). Co-learning computational and design thinking using educational robotics: A case of primary school learners in Namibia. *Sensors*, *22*(21), 8169. https://doi.org/10.3390/s22218169

Singh, K. (2015). The study of key factors resistance to change when adoption of new technologies in the companies. http://dspace.bu.ac.th/jspui/handle/123456789/1796

Shaturaev, J. (2022). Economies and management as a result of the fourth industrial revolution: An education perspective. *Indonesian Journal of Educational Research and Technology,* 3(1), 51-58.

Takavarasha, S., Cilliers, L., & Chinyamurindi, W. (2018). Navigating the unbeaten track from digital literacy to digital citizenship: A case of university students in South Africa’s

Eastern Cape province. *Reading & Writing-Journal of the Reading Association of South Africa*, *9*(1), 1-15. https://doi.org/10.4102/rw.v9i1.187

Tshidi, M. and Dewa, A. (2024). "The promise and peril of Coding & Robotics education in South Africa: A scoping review of teacher preparation and generative artificial intelligence's potential for delivering equity." Journal of Education (University of KwaZulu-Natal)(96): 140-164. DOI:10.17159/2520-9868/i96a08%20

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 1-10. doi:10.1186/1471-2288-8-45

Torres, K. M., & Giddie, L. (2020). Educator perceptions and use of technology in South African schools. *Peabody Journal of Education*, *95*(2), 117-126. https://doi.org/10.1080/0161956X.2020.1745611

Trucano, M. (2014). Promising uses of technology in education in poor, rural, and isolated communities around the world. Retrieved from the aaaaaaaaworld bank blogs.

Uzorka, A., Namara, S., & Olaniyan, A. O. (2023). Modern technology adoption and professional development of lecturers. *Education and Information Technologies*, 1-27. https://doi.org/10.1007/s10639-023-11790-w

Van der Bijl, A., & Oosthuizen, L. (2019). Deficiencies in technical and vocational education and training lecturer involvement qualifications and its implications in the development of work-related skills. *South African Journal of Higher Education*, *33*(3), 205-221. DOI: 10.20853/33-3-2886

Venkatesh, B., & Anuradha, J. (2019). A review of feature selection and its methods. *Cybernetics and information technologies*, *19*(1), 3-26. DOI: https://doi.org/10.2478/cait-2019-0001

Venkatesh, V. (2022). Adoption and use of AI tools: a research agenda grounded in UTAUT. *Annals of Operations Research*, 1-12. DOI: 10.1007/s10479-020-03918-9

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425-478. https://doi.org/10.2307/30036540

Venkatesh, V., Thong, J. Y., & Xu, X. (2016). Unified theory of acceptance and use of technology: A synthesis and the road ahead. *Journal of the Association for Information Systems*, *17*(5), 328-376. DOI: 10.17705/1jais.00428

Vinnervik, P. (2020). Implementing programming in school mathematics and technology: teachers' intrinsic and extrinsic challenges. *International Journal of Technology and Design Education*, *32*. https://doi.org/10.1007/s10798-020-09602-0, 213–242.

Vinnervik, P. (2022). Implementing programming in school mathematics and technology: teachers' intrinsic and extrinsic challenges. *International Journal of Technology and Design Education*, *32*(1), 213-242. https://doi.org/10.1007/s10798-020-09602-0

Walton, E., & Engelbrecht, P. (2022). Inclusive education in South Africa: path dependencies and emergencies. *International Journal of Inclusive Education*, 1-19. DOI: 10.1080/13603116.2022.2061608

Wentzel, J. P., Diatha, K. S., & Yadavalli, V. S. S. (2013). An application of the extended Technology Acceptance Model in understanding technology-enabled financial service adoption in South Africa. *Development Southern Africa*, *30*(4-5), 659-673. ttps://doi.org/10.1080/0376835X.2013.830963

Williams, M. D., Rana, N. P., & Dwivedi, Y. K. (2015). The unified theory of acceptance and use of technology (UTAUT): a literature review. *Journal of Enterprise Information Management*, *28*(3), 443-488. DOI: 10.1108/JEIM-09-2014-0088

Yang, Y., Long, Y., Sun, D., Van Aalst, J., & Cheng, S. (2020). Fostering students' creativity via educational robotics: An investigation of teachers' pedagogical practices based on teacher interviews. *British Journal of Educational Technology*, *51*(5), 1826-1842. DOI: 10.1111/bjet.12985

Yee, M. L. S., & Abdullah, M. S. (2021). A review of UTAUT and extended model as a conceptual framework in education research. *Jurnal Pendidikan Sains Dan Matematik Malaysia*, *11*, 1-20. DOI: 10.37134/jpsmm.vol11.sp.1.2021