p-ISSN: 2184-044X e-ISSN: 2184-1489 ISBN: 978-989-35728-0-1 © 2024
https://doi.org/10.36315/2024v2end108

EXAMINING PRE-SERVICE TEACHERS' USE OF CODING AND ROBOTICS DURING MICRO-LESSONS IN THE TEACHING OF CONSTRUCTION IN TECHNOLOGY THROUGH PROBLEM-BASED LEARNING

Patrick Thabo Makhubalo, Maglin Moodley, & Lydia Mavuru
Department of Science and Technology, University of Johannesburg (South Africa)

Abstract

Due to the technological advances of the Fourth Industrial Revolution (4IR), the South African education system revised its existing curricula to include robotics and coding. Such a development demands teachers to re-evaluate their pedagogical approaches to accommodate innovative technologies. However, using recent technology, such as robotics, in classroom activities adds complexity to teachers when engaging learners, as some students are not familiar with this teaching strategy and have limited knowledge of robotics technology. Additionally, meaningful robotics integration requires engaging students in small group activities. Still, interpersonal dynamics come into play, which can influence robotics task outcomes as the equipment is unavailable due to the high cost of robotics kits. Hence, there is a need to develop pre-service teachers professionally. The study explored pre-service technology teachers' integration of robotics technologies when teaching grade 9 structured construction topics. The Technological Acceptance Model (TAM) was used as the theoretical framework to interpret the data and ultimately frame the study findings. Following a qualitative research design, seven final year pre-service teachers enrolled for the Technology Methodology and Practicum module were purposefully selected to participate in the study, of which five participants were enrolled for the Bachelor of Education Degree and two participants for the Post Graduate Certificate in Education at a South African university. Firstly, the participants were developed on integrating robotics and coding when teaching Grade 9 technology structured construction concepts. The participants then planned and taught micro lessons. For data collection, each participant was observed whilst teaching micro lessons and then interviewed to determine their experiences of the development they received and their planning and teaching whilst integrating robotics and coding. Lesson observations and interviews were recorded in video and audio, respectively. Using Atlas Ti to manage the data, analysis followed a thematic approach, allowing for the identification of common themes and patterns in teachers' practices and experiences. Findings indicate that pre-service teachers acquired effective collaboration and engagement skills with learners, teamwork, and hands-on skills. The teachers acknowledged during interviews that the process not only equipped them in terms of creativity progress and pedagogical practices but also helped them to deepen their subject matter knowledge. As such, this study has implications for policy and implementation since it underscores the importance of developing pre-service and in-service teachers before implementing an innovation in any curriculum.

Keywords: *Coding, Fourth Industrial Revolution, pedagogical strategies, technology, robotics.*

1. Introduction and background

In recent years, educational institutions have increasingly adopted the Fourth Industrial Revolution (4IR) technologies, such as robotics and coding, to enhance the teaching and learning experience by fostering interdisciplinary learning and acquiring problem-solving skills as students apply critical thinking skills (Ehushi & Uribe, 2017). Robotics and coding have emerged as widely adopted in many institutions of higher learning to offer a robust framework for online learning. Understanding how students use and navigate digital platforms such as robotics being integrated during teaching and learning is essential for improving their learning experience as the educational paradigm continues to shift in favour of these tools (Makhubalo, 2023). Robotics technologies are further integrated into many universities to prepare students for the future world, as most jobs nowadays require employees with a technological background. Students being exposed to this technology are further opening opportunities to

engage in learning experiences that can fascinate their interest as they become more innovative, acquiring practical skills as they engage in hands-on activities and practical activities (Leoste et al., 2021).

Integrating robotics technology has become crucial for providing a flexible and interactive learning environment (Makhubalo, 2023). However, the success of these systems depends significantly on the effectiveness of the training provided to users (Sullivan & Bers, 2018). Understanding the perceptions and experiences of pre-service teachers during the micro lesson with the use of robotics is essential for improving the training process and ultimately enhancing their learning experiences and acquiring the competencies and skills demanded in the 4IR era. Hence, most universities embrace robotics and coding as they provide students with varying technological skills. This was also attested by Sullivan and Bers (2018), who mentioned that robotics empowers students and lecturers with the necessary skills for enhancing educational experiences.

Universities are essential in helping students get ready for various situations by trying to give them a well-rounded education that extends beyond specialized job training. According to Scott et al. (2019), universities empower students with knowledge and skills that are useful in the workplace and ensure that they have a technological background, which is regarded as one of the essential skills the employee must attain. Considering that robotics is a recent technology, most students showed interest in it as they became highly engaged towards the robotics activities within their STEM discipline; they learnt how to apply skills and integrate them into their academics to deepen their (Eguchi, 2017). Additionally, Anwar et al. (2019) mentioned that robotics improves students' engagement and interest in the subject as they acquire sufficient and new knowledge and academic performance in a range of STEM subjects and provide impactful learning experiences. Furthermore, Zhong and Xia (2020) emphasized that robotics integration needs careful preparation and deliberate intervention techniques to guarantee that students have a successful and fulfilling educational experience.

Student experiences and attitudes toward educational robotics are crucial for honing their skills within their STEM subjects' areas. Based on their attitudes and experience, a broad spectrum of affective behaviours, including commitment, acceptance, preference, and appreciation, are included in their experience and attitude (Kucuk & Sisman, 2020). According to the authors, it was observed that most of the students have more interest in robotics technologies, and many of them have fun, especially when creating robotic artefacts or solving robotics problems. Van der Merwe (2018) made the case that before pre-service teachers can become certified teachers, they should be given opportunities to grow as academic students and taught how to be creative and have effective teaching skills. Van der Merwe (2018) research further highlighted areas in which pre-service teachers need to grow to become qualified educators and acquire competencies skills. In the study conducted by Makhubalo (2023), it was observed that robotics and coding resulted in students learning through a hands-on approach and skills that enable them to physically interact with concepts and witness how theoretical knowledge is applied in real-world situations. It cultivates an innovative mindset and expands one's perspective. Because of this imperative, the study sought to explore pre-service technology teachers' integration of robotics technologies when teaching grade 9 structured construction topics.

2. Theoretical framework

This study was underpinned by the Technological Acceptance Model (TAM) theory by Davis (1989) to seek to comprehend and forecast users' adoption and acceptance of new technologies. Marangunić and Granić (2015) revealed that TAM explores how users accept and use technology based on the following two factors: the perceived ease of use and perceived usefulness. Nguyen et al. (2020) allude that the perceived ease of use is the level to which a person believes that using a specific technology will be effortless. In the context of this study, TAM assisted the researcher in identifying, after undergoing, students' experiences and attitudes on the acceptance of the use of robotics and coding in the teaching of construction within grade 9 Technology subjects. Another factor that TAM investigates is perceived usefulness. According to Portz et al. (2019), perceived usefulness refers to the level of a person's belief that using a particular technology is going to improve their job performance.

3. Methodology

This study adopted a qualitative case study research design to seek to comprehend the meanings, viewpoints, and experiences of pre-service teachers (Creswell & Creswell, 2017). This design allows the researcher to explore pre-service experiences while engaging with robotics technology to solve technology construction tasks during their micro lessons. According to Creswell and Creswell (2017), qualitative research methods are suitable for investigating, interpreting, and describing scenarios and obtaining a general (as opposed to precise) concept from the subjects. Through this research design, the

researcher could explore the use of robotics by pre-service teachers and fully understand the participants' attitudes and perceptions during their micro lesson observation and semi-structured interviews.

3.1. Selection of participants

This study adopted purposive sampling to select seven pre-service teachers majoring in technology as their methodology major within the faculty of education. Etikan et al. (2016) mentioned that purposive sampling is a deliberate choice of a participant due to the qualities the participant possesses. Seven participants were selected for this study. These participants include both male and female students. Criteria for selection will include that the student must be registered with the University of Johannesburg in the faculty of education, must be in a final year or must be enrolled for a post-graduate certificate in education (PGCE) majoring in technology as their major. Pre-service teachers must have undergone robotics and coding training to ensure that they have a baseline understanding of this technology and can operate it.

3.2 Data collection and analysis

Data was collected through semi-structured interviews and observation during micro-lessons. According to Longhurst (2003), a semi-structured interview is a conversation in which the interviewer asks questions of the other party to get information from them. Conversational, semi-structured interviews enable participants to delve into topics they deem pertinent to themselves (Longhurst, 2003). Each interview took approximately 20-30 minutes. Interviews were audio recorded with permission from the student and then transcribed using Microsoft Teams application software. Seven pre-service teachers were observed using OSMO cameras as they had micro lessons with robotics technology. The researcher taped every session, which lasted 20 to 30 minutes for each student. After the observation, the researcher uploaded the videos to Google Drive for cloud storage. The researchers accessed these videos and watched them multiple times to assess the efficacy and caliber of students' engagement. After that, they were uploaded to Microsoft Stream to be transcribed.

4. Findings

Pre-services stated that they had an excellent experience integrating robotics technologies during their micro lessons. What worked to their advantage was that they could engage in hands-on skills activities, which enabled them to be involved in practical experiences rather than theory. Through this experiment, they utilized robots to construct and build blocks, which permitted them to create a robotics learning artefact after completing the task. It is evident that robotics technologies enable pre-service teachers with hands-on skills as they become more creative and acquire innovation skills when solving robotics activities such as building house blocks. As pre-service were sharing their experience, they expressed their happiness and excitement about their robotics experiment. Some outlined that this technology empowered them to explore more competencies skills while teaching as they enhanced computational thinking, critical thinking, innovation, and creativity skills in their teaching instructions.

In addition to the experiment, some pre-service teachers mentioned that during their micro lessons, they could relate concepts of construction topics in reality as a result of robotics. While they were teaching, it was easier for them to apply theory concepts into practice. Participant T1 shared his thoughts regarding his experience.

T1: *Utilizing robotics and coding was a great innovation in my classroom presentation, and made learning interesting as it grasped the attention of students since they linked knowledge they have learnt in the class while solving robotics tasks. Students were excited to learn, they absorbed the task information effectively. This integration allowed hands-on activities, which benefits psychomotor students because mostly these types of students are not accommodated, as teachers are active and students are passive. Thus, student engagement was fostered.*

The response indicates that robotics technologies permit pre-service teachers to contribute by proposing innovative solutions and engaging in hands-on activities while focusing and paying attention to the task. The findings also found that integrating robotics technologies into the classroom provides a dynamic and engaging learning experience. It imparts valuable skills that are relevant to the fourth industrial revolution, encourages creativity and innovation, and prepares students for a future world driven by technology. Some pre-service teachers pointed out that robotics empowered students as they engage in learning activities; they become motivated and willing to explore and solve complex activities in a technology subject. The following response from Participant T2 is evident to this:

T2: *What I observed during the micro lessons was that students were motivated to exceed expectations when completing tasks. They demonstrated a willingness to learn new tools and apply their experience to create new tasks within their methodologies. They did another task as some were able to build electrical circuits without being instructed by me.*

Due to the experience with robotics technologies, some pre-service teachers view this technology as an effective tool for teaching. They mentioned that students could have a better understanding of content as robotics deepened students' understanding of subject content. In addition, they indicated that robotics is effective in enhancing meaningful explanations of technology and scientific concepts. From other pre-service teachers' responses, robotics allowed students to be committed to their activities by actively and effectively participating in achieving the task goal and making the robotics task successful.

Pre-service teachers' utilization of this technology in their micro lessons allowed them to engage their lessons in cooperative learning, where students were highly engaged and committed towards the task. As a result of limited robotics technologies, they were encouraged to use cooperative learning as they had to share the resources and engage in groups. Some pre-service teachers attested that this learning strategy was highly effective as students put more effort into the project's success, allowing them to support each other by sharing innovative ideas and engaging in hands-on contributions while connecting those robotics technologies to build their projects. To attest to the statement above, Pre-service Teacher 4 had the following to say.

T4: *Students were putting ideas together and discussing solutions as a group while building those blocks. The first thing they did in their groups was to collaborate, share ideas, discuss, and agree on one thing while building their blocks.*

Some pre-service teachers mentioned the complexity of this technology in teaching technology subjects, which is linked to troubleshooting and operation skills. They revealed that although they managed to use these robotics effectively in their micro lessons teaching, they experienced some challenges as they had limited knowledge of robotics. This challenge delayed them to complete their task and lesson in time as they spent much time trying to troubleshoot. Pre-service Teacher 5 participant made the following explaination:

T5: *I found it difficult as sometimes the robot could not work and that was the biggest challenge I experienced.*

Unfamiliarity with robotic equipment due to a lack of exposure has a considerable detrimental impact on the pre-service ability to learn with robots. In some instances, pre-service teachers indicated that one challenge they encounter is a lack of exposure to these technologies. They outlined that the universities buy limited robotics resources as they are costly. Furthermore,lecturers who have a solid background in robotics and coding. As a result, pre-service teachers being prepared for this innovation must be prepared to receive training in robotics and coding, and apply it in the classroom. These pre-service teachers pointed out that the lack of robotics resources at universities contributes to students' failure to develop knowledge and skills in robotics and coding, hampering them from using them in their learning and highlighting that the lack of availability of robotics learning tools further sets learners back in acquiring the relevant knowledge and skill. This came from Participant T6's response.

T6: *I think these robots are not enough for us to use, sometimes it takes time for us to have training sessions as the queue may be long. If universities can buy enough robots I think it will be better for all of us.*

5. Discussions

Pre-service teachers have indicated that their robotics experience was effective as it enhanced students' self-directed learning and allowed them to explore their skills to solve complex problems within technology tasks. These findings concur with Lee et al. (2016), who attested that students engaging in groups using robotics technology provide them with more opportunities to explore and create new tasks. As they solve technology problems, they become motivated by their achievements and the knowledge and skills they gain. As a result, they are eager to learn more about robotics technology and apply it to scientific and technology tasks. As students engaged in this kind of learning, Makhubalo (2023) highlighted that robotics technology plays a significant part as it permits students to be highly engaged in their learning tasks while solving problems. This supported Keith et al. (2019), who found that students who participated in learning activities using technology tools discovered new opportunities to explore and create projects. They are encouraged by their achievements and the knowledge and skills they acquire.

6. Conclusion

This study examined pre-service teachers' use of coding and robotics during micro-lessons in teaching construction in technology through problem-based learning. The findings revealed that pre-service teachers' experience with robotics technologies was effective as they could deepen subject knowledge among students while teaching. They could integrate theoretical concepts of technology subject into reality while solving robotics problems. These findings further showed that students were highly engaged throughout the lesson and could share responsibilities while solving tasks. As they engaged in their learning activities, pre-service teachers enhanced hands-on skills among students as they were building and designing blocks. As a result, students developed competencies such as creativity, critical thinking, innovation, and problem-solving skills. These findings have implications for professional and competency development to enhance pre-teachers' knowledge and skills in teaching in digital or virtual environments where robotics technology is being used as a tool to enhance learning.

References

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.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage publications

Eguchi, A., & Uribe, L. (2017, March). Robotics to promote STEM learning: Educational robotics unit for 4th grade science. In *2017 IEEE Integrated Stem Education Conference (ISEC)* (pp. 186-194). IEEE.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1-4.

Keith, P. K., Sullivan, F. R., & Pham, D. (2019). Roles, collaboration, and the development of computational thinking in a robotics learning environment. In S.-C. Kong, & H. Abelson (Eds.), *Computational Thinking Education* (pp. 223-245). Singapore: Springer.

Kucuk, S., & Sisman, B. (2020). Students' attitudes towards robotics and STEM: Differences based on gender and robotics experience. *International Journal of Child-Computer Interaction*, *23*, 100167.

Lee, H., Parsons, D., Kwon, G., Kim, J., Petrova, K., Jeong, E., & Ryu, H. (2016). Cooperation begins: Encouraging critical thinking skills through cooperative reciprocity using a mobile learning game. *Computers & Education*, *97*, 97-115.

Leoste, J., Jõgi, L., Õun, T., Pastor, L., San Martín López, J., & Grauberg, I. (2021). Perceptions about the future of integrating emerging technologies into higher education – the case of robotics with artificial intelligence. *Computers*, *10*(9), 110.

Longhurst, R. (2003). Semi-structured interviews and focus groups. *Key Methods in Geography*, *3*(2), 143-156.

Makhubalo, P. T. (2023). *The nature of collaboration in Grade 6 Natural Science and Technology Robotics and Coding Learner group projects* (Doctoral dissertation, University of Johannesburg).

Portz, J. D., Bayliss, E. A., Bull, S., Boxer, R. S., Bekelman, D. B., Gleason, K., & Czaja, S. (2019). Using the technology acceptance model to explore user experience, intent to use, and use behavior of a patient portal among older adults with multiple chronic conditions: descriptive qualitative study. *Journal of medical Internet research*, *21*(4), e11604.

Scott, F. J., Connell, P., Thomson, L. A., & Willison, D. (2019). Empowering students by enhancing their employability skills. *Journal of Further and Higher Education*, *43*(5), 692-707.

Sullivan, A., & Bers, M. U. (2018). Dancing robots: integrating art, music, and robotics in Singapore's early childhood centres. *International Journal of Technology and Design Education*, *28*(2), 325-346.

Van der Merwe, H. (2018). The vocational calling of female primary school teachers teaching in environments of multiple deprivation. *Gender Questions*, *6*(1), 17-pages.