**Case Studies: The Impact of Artificial Intelligence on STEM Education**

Artificial intelligence can improve the quality of teaching and learning in education. It can have a more positive impact by serving as a new special purpose “method of intervention” that can change our curriculum in education. Artificial intelligence refers to technology that is reacts to its environment and responds to tasks in a way that optimizes the levels of success. In this chapter I address certain tasks which were carried out by educational robotics and learning management systems that could maximize the success of teaching and learning, specifically in Mathematics and computer science education. The two types of technology we discuss in this chapter are robotics and a learning management system. I consider these two types of technology in a general setting and provide examples of actual usage in classroom situations. The author presents for each type, an example of intervention of the artificial intelligence. In the case of robotics, research was carried out with preservice computer science teachers (n =75). These teachers were asked about their experiences when utilizing robotics when learning computer programming. Kolb’s Experiential Learning Cycle guided that study. In the section that follows I surveyed potentials of robotics in STEM Education. In the case of using the learning management systems, a mixed mode research study was carried out with science students in one study and then with engineering students (n =162) learning mathematics. It was found that there is ample potential for the use of artificial intelligence in education to enhance teaching to support more effective individualized learning. I show in this chapter the benefits when using educational robotics and the learning management systems for teaching and learning in education with pres4ervice teachers and engineering students.

Keywords: artificial intelligence, education, learning management systems, robotics.

**Introduction**

The Learning Management systems (like Moodle) is AI driven. At its core, AI in LMS uses machine learning and natural language processing to automate and enhance various aspects of the learning process. From creating personalized learning paths to providing actionable insights into learner performance, AI is setting a new standard for what technology can achieve in workplace learning. At universities in South Africa we use the LMS to encourage blended teaching and learning in our pre-service mathematics courses. We also report on how the use of robotics with preservice teachers. The design of robotics is also AI driven

In this chapter we surveyed empirical studies which explored how certain AI mechanisms could be used to facilitate or support learning in mostly in education. The first part of this chapter reviews already published work on robotics in action in education. A South African study is discussed firstly followed by studies invoking robotics in teaching and learning in the USA and Greece. The second part of the study reports on how the Learning Management Systems (LMS) can be implemented when teaching and learning mathematics at especially the undergraduate levels at universities. The first study works with science students and the second with engineering students.

**Use of Robotics in the learning of Computer Programming**

A problem that faces South Africa is that students are exposed to the principles of coding at a very late stage of their learning. Robotics is introduced much later. In most of the other specializations early exposure to concepts are done in the previous phases lay a foundation for these subjects in the Further Education Training (FET) phase. It is only the final 3 high-school grades (FET phase) that coding as a topic within the subject of Information Technology is provided as an option to learners. This makes scaffolding within the Zone of Proximal Development (ZPD) a challenge for teachers to implement so that there is greater efficiency in student success. ZPD is usually defined as knowledge a student can gain with the guidance by the teachers when facilitating scaffolding. In this way student knowledge development addresses the “gap” when accommodating and assimilating the development of new information. Students coming into the FET phase lack prior knowledge to programming, thereby having trouble in building new knowledge from any foundation, thereby facing the subject as a challenge, and treating coding as an abstract concept. As a result, most students avoid courses involving computer programming at universities and colleges. Consequently, computer programming courses are therefore seen as demotivating and uninteresting. This contributes to a high dropout rate at tertiary level. Hence, that study by Govender & Govender (2023) investigated the implementation of robotics as an enhancement strategy for the teaching and learning of Computer Programming. For this investigation they asked the research question: What are students’ experiences of using robotics when learning to program?

Learning institutions have adopted a variety of tactics to overcome this issue and introduce students from beginner backgrounds to the fundamentals of coding. Considering these initiatives, the goal of the study by Govender & Govender (2023) was to determine whether including robots in computer programming courses can help the learning process even more. In the twenty-first century, computational thinking (CT) is a critical talent, and exposing students earlier to computer science is essential for promoting and developing all aspects of computational thinking. Robots can be programmed in educational robotics to give students the chance to interact with real world things and build their knowledge. This strategy promotes critical thinking, analysis, and problem-solving for actual issues. The field of educational robotics provides possibilities to advance CT, code, and engineering while also providing opportunity to advance literacy, mathematics, social subjects, dance, music, and the arts. Learning professionals are increasingly using robotics in educational settings to teach a variety of subjects and domains.

The lack of early exposure to coding and robotics concepts in South Africa is related to the study problem, which consequently halted learning and interest in computer programming. The goal of that study was to investigate how a particular intervention, the employment of robots and microcontrollers enabled students to learn computer programming while taking their prior knowledge into account. The contributions from that research advanced creative approaches to teaching computer programming through robotics.

The Kolb Experiential Learning Cycle, often known as the KELC, was used as a theoretical framework in that study. This cycle has four steps, which are sequentially engaged: Concrete Experiential, Reflective observation, abstract conceptualization, and active experimentation. This cycle and related exercises were used to develop a prototype utilizing the Arduino microcontroller robot kit.

Each workshop's activities were carried out in accordance with the cycles found in the KELC's architectural design. Pre-designed exercises that focused on the Zone of Proximal Development and built on preexisting resources, concepts, and knowledge were obtained from a variety of sources. Using a so-called "learning path" within an LMS, the design of an online learning framework was completed.

Method-based research (DBR), or intervention design, was employed in that study. The study's goal was to give university students of programming a more scenario-based, learner-centered approach to learning coding in a text for the language used in programming. In addition to workshop activities, Likert scale questionnaires, and focus group interviews were used and so that study adopted a hybrid methodology for data collecting.

Six online workshops were conducted to develop and gather data for that project. Each session focused on the Zone of Proximal Development while also incorporating prior knowledge. In that study, a variety of non-probability sampling strategies were also used, such as pairing a Likert scale survey with a focus group interview.

The outcomes of each workshop session are briefly summarized below:

* Participants learned about the Arduino kit's components and began writing their first programs, in the first workshop session.
* Participants learnt about conditional statements and user input. This session's high point was creating a prototype traffic robot system, in the second workshop session.
* In the third workshop session, participants looked more closely at nested and repeated structures. The night sensor prototype was this session's high point.
* In the fourth workshop session, participants improved their use of repeating structures and worked with a variety of Arduino components, including sensors. The creation of a fire alarm prototype was the session's high point.
* Participants created a seismic detector in workshop session 5 utilizing buzzers and tilt sensors.
* Participants used previous code structures and fiddled with layered structures in workshop session six. The Fibonacci sequence-based actuator movement coding was the session's high point.

A Likert-scale survey was undertaken to get early student impressions on coding and robotics in addition to the workshop results. The survey received a variety of responses, the majority of which fell at either end of the Likert scale. Most items fell in the strongly agree or strongly disagree position of the scale. However, replies to queries about the form and complexity of programming were more varied. The findings show that the workshop activities were rather simple for the participants.

Many varieties exist depending on the precise duties and ideas covered in each session. The use of robotics in computer programming education appeared to enhance participants' learning and engagement. It investigated participants' responses to focus groups and Likert scale surveys. The following are the key findings:

Most students (97.34%) strongly agreed or agreed with the statement that they are interested in programming. Some students voiced concern regarding their interests, maybe because of the inclusion of both coding and robotics components. It turns out that one of the main factors encouraging pupils to learn programming is the usage of manipulation tools like robots. Fifty seven percent of students disagreed with this assertion or did not agree with it at all. Some pupils (18.67%) strongly agreed or agreed that they had no substantial background in mathematics. Math confidence can boost your self-assurance and sense of self-efficacy, both of which can enhance your programming ability. Thirty seven percent thought programming was technical. The statement that programming is too technical was opposed with or disagreed with entirely by some students (32.0%). Because the learner is unfamiliar with computer programming, the answers give a relatively complicated understanding of the technical components of programming. All the students were confident in their ability to learn to code, and the vast majority (68.00%) concurred. In terms of self-awareness and self-efficacy, students showed high levels of self-esteem, which are elements that support intrinsic motivation and reported enjoyment of programming.

Overall, the findings showed that most students were enthusiastic about programming and thought they could learn it. They had a good disposition when it came to fixing issues. Opinions on the type and degree of programming challenge as well as the usage of manipulative techniques differed. Robots and microcontrollers had played a significant influence in arousing their curiosity and fostering an interest in programming.

The study's students' learning experience was significantly impacted using microcontrollers. The following are some significant ways that microcontrollers impacted their learning:

* Hands-on Learning: The usage of microcontrollers gave the learning process a tangible component and allowed students to participate in hands-on activities. This practical approach made the learning process more engaging and concrete, which raised student motivation and engagement.
* Concrete Experience:For the students, using the microcontrollers provided a practical experience. They could view and interact with the actual hardware, including LEDs, sensors, and actuators, which made it easier for them to learn the principles of coding and circuitry.
* Application of Knowledge: The students were able to control the microcontrollers and produce practical prototypes by using their programming skills. The learning process became more meaningful and pertinent to their interests and objectives thanks to this application of information.
* Problem-Solving Skills: When using microcontrollers, students must exercise problem-solving skills and critical thinking. They needed to debug the code and fix the issue. To achieve the desired outcome, adjust. This improved my capacity for problem-solving and sparked my imagination.
* Positive Attitude: Students' attitudes toward studying computer programming improved because of the employment of microcontrollers. They thought the exercise was valuable, intriguing, and fun. The physical characteristics of microcontrollers have improved and shortened the learning period.
* Self-efficacy: The pupils' confidence in their programming abilities grew because of using a microcontroller. They felt that studying computer programming would benefit them and would make it easier for them to deal with difficulties in programming.

**Potentials of Robotics in STEM Education**

In this section we discuss a study by Ioannoui and Makridou (2018) in which they reviewed published work on the overlap of Computer Thinking (CT) and educational robotics, specifically targeted the implantation of educational robotics for enriching students’ CT skills in high school. The articles which were reviewed revealed prior signals to make a case that educational robotics fostered students critical thinking and advancing their social skills. Their study discussed focussed areas for future exploration by university academics, practitioners, and researchers. Such exploration they thought should commence from a universally accepted definition of CT and validated measurement tools for its assessment. A more useful framework that will lead to the advancement of CT via robotics is expected to be in demand. Curriculum designers and educators could make use of such a framework widely and consistently.

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Computer thinking (CT) is the process of formulating problems and their solutions to be implemented by humans or computers. It focuses on the capacity to think like a computer scientist when faced with a problem. The term has gained attention in Grade twelve high school education, but there is no universal definition or theory of its practice and assessment methods. Efforts have been made to assess CT using visual languages, such as Program Behavior Similarity (PBS) and the Computational Thinking Pattern Graph (CTPG). Other approaches, mainly in elementary schools, include project portfolio analysis, user analysis tools, event-driven programming, initialization, synchronization, and animation, and the PECT Model for elementary students.

Educational robotics were designed at a university to teach and develop skills through design, constructing and operating robot platforms and advancing CT, coding, and engineering. They can be used in various disciplines such as STEM, social studies, literacy, art, dance and music. Recent evidence supports the potential of teaching CT using educational robotics. However, there is limited research on the overlap of educational robotics and CT and the impact of robotics in promoting CT need validation through research evidence. This review aimed to widen the dialog and provide useful information for future research in this emerging space.

In that survey nine studies on CT- educational robotics were done. The first author conducted a database search using keywords education, robot, and B computational thinking, resulting in thousands of manuscripts from various electronic databases. The first author also conducted a tedious process of filter studies on the use of educational robotics in grade 12 high school for advancing students CT skills. They excluded theoretical or position papers and excluded papers that limited CT to isolated skills. Only nine papers were independently reviewed by the second author to make sure that the correct exclusion criteria were applied. Independently, nine papers were read to identify theoretical assumptions, research designs, experience setting, roles, procedures, learning outcomes and aspects of assessment. Authors presented synthesized findings, analyzing the platform and context implemented in each study of computational thinking via educational robots. In this chapter we thought of reporting on those studies as their findings still impact our teaching and learning especially at the university level.

In terms of the theoretical underpinnings for exploring the use of robots, we consider three possibilities. Constructionism, constructivism and learning for use are theoretical approaches that emphasize the learning process through educational robotics. Constructionism, an extension of Piaget’s constructivism, suggest that knowledge is actively built up in the learner’s mind through interaction with physical artifacts and hand-on projects-based learning experiences. Learning for reason, a technology design framework, emphasizes incremental knowledge construction, goal- directed learning, situated knowledge need to support knowledge construction. However, a direct link between practice and theory is not evident in the reviewed studies. A framework that has practical use for developing CT through robotics is certainly in demand.

Educational robotics which was designed at a university were primarily used in studies conducted within school settings. Atmatzidou and Demetriades (2016) conducted 11 robotics sessions in certain non-private schools in Thessaloniki- Greece and Ber (2014) conducted 60–90-minute sessions in three kindergarten classrooms and Grover conducted 8 hours per day in 2 public schools in Chicago. These studies presented a constructivist learning environment, bridging abstraction and reality, helping students develop creativity in problem-solving and learning adaptations in social skills. However, decision about how long their experiences last in regards to particular learning outcomes or curricular aspects were inadequately brainstormed in the surveyed studies, making it a challenge to assist guide forthcoming studies and repat of similar studies in different geographical locations.

**Techniques and roles**

The roles of learners and instructors in robotics education are consistent across studies. Lecturers typically act as facilitators, providing guidance for technical issues and encouraging students to actively participate with the technological platforms. Students are encouraged to play, design, and reflect on the learning process, constructing their understandings. In Leonard et al.'s (2016) study, students studied programming and coding to create a robot using Lego Mindstorms EV3. In Grover's (2011) study, researchers and assistants facilitated workshops, data collection, and scaffolding.

Students were expected to engage in activities, oversee progress, and present reflections. In Berland and Wilensky's (2015) study, instructors demonstrated the physical/virtual robotics system, while students programmed the robot, collaborated, and applied knowledge. Overall, to encourage a constructivist approach a student-centered, was encouraged in all the studies reviewed. However, not one of the studies expanded on the rationale for selecting robotics platforms, and the goals for learning in respect of the curriculum were not sufficiently discussed. This made it difficult to test hypotheses about the contribution the different platforms linked to specific curricular objectives could afford.

Assessment of the learning outcomes for CT varied across studies. Atmatzidou and Demetriadis (2016) used various tools to assess students' understanding of concepts in CT and their learning perceptions. Eguchi (2014a, b) used an online questionnaire to measure students' learning outcomes in STEM, their CT skills, and their engineering thinking. Grover (2011) assessed students' prior technological experiences through questionnaires and interviews. Berland and Wilensky (2015) used video data, interaction logs, and pre/post-tests to measure students' CT skills.

Leonard et al. (2016) used a mixed mode approach in retrieving data to assess the CT development during game design. Penmetcha (2012) analyzed data from a pre/post-test instrument to measure participants' experiences in robotics, and algorithmic thinking.

Lack of validated measurement instruments for CT in reviewed studies raises doubts about students' progress. Although educational robotics has led to the development of 21st-century skills, the advancement of complex abilities like decomposition, abstraction, algorithms, and debugging remains unclear. Eguchi (2014) highlighted collaborative learning, engagement in problem-solving, and peer interactions as learning gains, while Leonard et al. (2016) reported on the success achieved when technology-related activities are provided as learning opportunities Inclusive assessments and validated CT instruments are necessary for integrating CT skills in curriculums.

The research on CT development using educational robotics provided evidence of improved social and thinking skills that can arise as a consequence of the use of robots. However, challenges remained unexplored. Recommendations for young scientists and practitioners to guide further research and address identified challenges.

**Recommendations for young scientists**

The review by Ioannoui & Makridou (2018) highlighted four areas that require further study and clarification:

* Agree on the operational definition of CT. Having not reached consensus on what the definition of CT, makes it challenging to develop an approach through robotics. A consensus operational definition is needed before integrating CT at universities.
* Establish validated instruments for CT assessment. Despite previous attempts, systematic assessment methods for CT components like abstraction, automation, and analysis are still in progress. This complicates learning the importance in the use of educational robotics in advancing CT.
* Research educational robotics classroom orchestration, as it can create additional work for teachers, as they must plan creative and cooperative learning experiences and provide arrangements for interaction between students and smaller groups. This research focuses on classroom lesson design, which emphasizes the importance for supporting lecturers or researchers in managing use of technology in real classroom situations.
* Design a realistic framework for developing CT teaching and learning design through robotics. The community of practice for computer science education can indulge in a crucial role in improving the application of CT across related areas by integrating CT. Educational robotics can provide students with the added benefit of handling of concrete objects and thereby construct knowledge in a more effective manner.

**Recommendations for learning practitioners**

Ioannoui & Makridou (2018) indicated that the three directions for learning practitioners can help address challenges when engaging with educational robotics in student learning. First, design a CT curriculum through robotics, as there viewed studies lack adequate information on the curriculum and learning goals. Additionally, create a repository of available educational robotic platforms to understand their capabilities and limitations. This will help practitioners involve educational robots in their teaching design and assess their value linked to specific curricular aims and outcomes. Second, consider detailed descriptions of the integration of robotics to understand the processes and conditions under which specific roles of CT and whether the desired outcomes are attained. This will help in replication and expanding research areas such as classroom curricula design and orchestration.

Students can collect and engage with data thanks to the computing capabilities embedded in primary school classrooms via digital manipulatives such pattern blocks, geoboards, and LEGOs. With the help of these manipulatives, which are based on constructivist learning theories, young people can actively create knowledge based on their own experiences. Digital manipulation features are embodied by educational robotics and GPS devices, enabling hands-on, self-directed learning. According to research, educational robotics can help students learn STEM topics more effectively, enhance problem-solving, and foster cooperative learning. Middle school students can learn project-based science, environmental education, and geography themes using geographic information systems (GIS), which will aid in the development of their analytical and problem-solving abilities.

It has become evident that innovative technology platforms inspire and attracts young people to careers in technology involving robots. In the STEM fields, attitude factors are crucial, including students' goals, self-confidence, and giving meaning to STEM tasks and activities. High levels of youth participation and interest in robotics encourage them to pursue jobs in math and science.

Students in the GPS/GIS and robotics program spent 40 hours at a summer camp and met once a week as a 4-H club or a program after school. The course teaches participants how to construct and program robots using the LEGO Mindstorms NXT robotics platform, as well as how to use handheld GPS devices and ArcMap GIS software. Students study aerial photography, mapping, GIS, and map symbiology while integrating a GPS receiver for geo-tracking with an NXT robot. They also learn about GPS concepts. The program uses specially created software modules to integrate instructional robotics and GPS/GIS technology. Activities may be carried out in the open air, on tennis courts, or in school yards.

The course also covered useful agricultural production techniques like field scouting, tree harvesting, and weed spraying. Project employees supervise camp programs, which were planned by a European university.

That project team had spent three years studying robotics and GPS/GIS interventions. In 2006, research conducted with hundred and twenty one children participating in a robotics program done after school, STEM concept scores significantly improved from the pretest to the posttest. The control group did not exhibit a notable rise. Thereafter, a summer camp study discovered appreciable improvements in engineering, programming, and arithmetic topics. The increase in geospatial ideas was slight but not statistically significant.

Previous studies on GPS/GIS interventions in robotics boost STEM learning and interest, but most of them lack scientific rigor, sophisticated statistical analysis, and experimental control. That study focused on STEM attitudes and learning and employs a control group of young people.

Ioannoui & Makridou (2018) strongly believed that the use of microcontrollers in education has greatly enhanced the learning environment and raised awareness of computational thinking (CT) and computer programming. These assertions are, however, partially supported by empirical data. A practical framework for adopting CT using robotics is required for consistent and widespread deployment, as well as a broadly accepted definition and proven measuring tools. Robotics and geospatial technologies in education promote creative, hands-on learning and incorporate STEM subjects into student projects.

**Educational robotics and global positioning systems**

Nugent, Barker, Grandgenett & Adamchuk (2009) reported on their study on global positioning systems (GPS) receivers and educational robotics depicted characteristics of digital manipulation which allowed to expand academic achievement in areas aligned with the high school curriculum with specific STEM concepts.

Nugent, Barker, Grandgenett & Adamchuk (2009) in that study examined the possibilities of robots and GPS/GIS interventions. A control group of young people participated in that study, which concentrated on STEM learning and attitudes. The comparison group included 141 students, whereas the robotics treatment group included 147 students. Schools chose the control group to include a variety of student talents, interests, gender, and ethnicities. The control group took part in a three-hour robotics exploration activity.

An improved version of a 37-item assessment tool, which included themes in computer programming, mathematics, geospatial concepts, engineering, and robotics, was used in the study. Experts validated the assessment. The same evaluation tool, with a Cronbach's alpha reliability coefficient of. Eighty, was employed in the post-test. Motivated Strategies for Learning Questionnaire served as the basis in the development of the attitude instrument, which consists of thirty-three items on a Likert scale. Questions gauging young people's effective use of GPS/GIS tasks and robotics were part of the motivational component.

Questions about the students' opinions of the worth of science, math, robotics, GPS, and GIS technologies were also included in the part on motivation. Teamwork and problem-solving were highlighted in the section on learning methodologies. To promote teamwork and inspire students to collaborate with peers to approach and succeed in certain challenges, the teamwork scale was added. The recommended Standardized Root Mean Squared Residual (SRMR), Root Mean Square Error of Estimation (RMSEA) was aligned with the motivation construct. This motivation construct ensured that the Cronbach’s alpha reliability coefficient of. Eighty when it was used in the factor analysis of the attitude instrument was in line.

Using learning and motivation methodologies, a confirmatory factor assessment technique was performed on the attitude instrument. While the learning component fulfilled acceptable standards, the motivation construct met recommended fit criteria. The dependability of Cronbach's alpha was.95. Pre-test material and attitude assessments were given by teachers in the classes, and post-tests were given a week later in a manner that mirrored robotics therapy methods. The study compared robots to control groups using a quasi-experimental approach, with data analyzed using ANCOVA. Student learning and STEM attitudes were the dependent variables. For the results related to cognition, a split plot ANOVA was performed.

To naturally allow for the introduction of STEM concepts within the student robotics activities, the youth were provided opportunity to build, test, and reflect on the successes of their robotics/geospatial projects. Educational robotics combined with geospatial technologies appeared to promote creative, hands-on, and self-directed experiences. According to Nugent, Barker, Grandgenett & Adamchuk (2009) summer camps gives kids the ability to engage in STEM activities to a greater extent than could be viable in more formal educational contexts, in which the usual time restraints make sustained engagement with a particular STEM application more challenging.

Nugent, Barker, Grandgenett & Adamchuk (2009) believed that their study indicates the advantages of student interactions may well include increased interest and expanded STEM conceptual knowledge, in the study of engineering, science, and technology. Also students can benefit increased success in carrying out technologically based tasks, and thereby develop a greater use of efficient problem-solving techniques.

**Application of LMS with university Science students**

We have observed, in the decade, a complete change in pedagogy in undergraduate courses at universities. This has mainly been due to the advent of technological developments. At a South African university, mathematics educationists (Maharaj, Brijlall & Narain, 2015) created a digital environment for their classroom interaction during the teaching and learning of undergraduate mathematics. These lecturers thought that this intervention was necessary given the poor performance in mathematics. The university where the lecturers work at, provides the learning management system (LMS) Moodle. This platform is available for both lecturers and students. Maharaj, Brijlall, & Narain (2015) explored these facilities of this platform to fulfil the need for improved mathematics performance. They reported on the various teaching and learning opportunities available on this Moodle platform. They communicated with the students via mobiles and PC tablets. Lecture notes were placed on this platform for student reference.

They also placed online diagnostics for pre-calculus on the Moodle platform. This platform showed numerous advantages. For example, data retrieved from this platform provided the frequency in student engagement with the various activities. The data was analysed keeping in mind the aim of their study. The ontological model by Aroyo and Dicheva (Maharaj, Brijlall & Narain, 2015) guided the design and implementation of the online learning material. The findings of their study provided many vital pedagogical attributes for greater effective pedagogy. The study also expanded the theoretical ontological model used in that study.

Their observations indicated that many institutions used diagnostic measures to assess the readiness of students to study pre-calculus. In their project their focus was on the design and implementation of expected learning outcomes and diagnostic tasks for pre-calculus and in-course diagnostics tasks relating to continuity of functions, elementary logic, limits and the derivative and its applications, integrals and their applications, basic concepts in linear algebra, and vectors and their applications in 3-dimensional space. This contributed to the knowledge fields on expected learning outcomes and diagnostic testing, with reference to in-course content for undergraduate mathematics. With these thoughts They formulated their main research question being: *How could MOODLE be used as a platform to promote more efficient mathematics teaching and learning strategies in a blended learning context?* They then drafted sub-questions to unpack the main critical question. The sub-questions were: (1) What should the general design for a module template be? (2) How could a PC tablet be used as a cutting instructional technology for mathematics?

Maharaj, Brijlall & Narain (2015) made sense of how students at that South African university were taught. Written responses of these undergraduate students were studied by these researchers. They searched for possible mental conflicts which arose and displayed in the students’ written responses. Once the mental conflicts in basic algebra were detected, web-based activities were designed. These activities were designed with the intention of removing or decreasing the observed mental conflicts. Using Zhao and Orey (Maharaj, Brijlall &Narain, 2015) principle of scaffolding, web-based activities were designed and implemented. The many different mental conflicts were analysed against the five strands of mathematical proficiency (Kilpatrick, 2001). The classroom interaction between the students and the web-based activities during tutorial sessions were brainstormed and discussed by these researchers. They indicated that the web-based activities helped in removing the common mental conflicts which many of these undergraduate students displayed. The mathematical notation and terminology improved the students’ mathematical vocabulary. These led to these students better interpreting problem statements. The learner support materials from the study by Maharaj et al. (2015) are intended to be used by the mathematics education department at that university. Studies on teachers’ pedagogical knowledge (Bansilal, Brijlall & Mkhwanazi, 2014; Brijlall, 2014; Brijlall & Maharaj, 2014) have suggested use of technology in providing support materials for teachers offering to specialise in high school mathematics teaching.

The study by Maharaj, Brijlall & Narain (2015) used a qualitative methodological approach. This was considered an appropriate approach as it provided a deeper understanding and explanation of the use of MOODLE to promote a blended approach to the teaching and learning of first year university mathematics involving students studying towards a Bachelor of Science (BSc) degree. Qualitative research methodology by its nature permits the use of different research strategies to gather data (Cohen, Manion & Morrison, 2011). It allowed for a variety of methods to be used in the data capture.

That study by (Maharaj, Brijlall & Narain, 2015) provided answers to the question: (1) What should the general design for a module template be? (2) How could a PC tablet be used as a cutting instructional technology for mathematics? Firstly, it proved that the ontological model formulated by Aroyo and Dicheva (Maharaj, Brijlall & Narain,2015) could be useful in the setting up of a computer based LMS environment for blended mathematics teaching and learning to occur. Secondly, they found that the various stages involved in this process were effective in attaining the objectives of the researchers in this study. The MOODLE platform could provide an interactive mean for communication between the lecturers, mathematics subject content and the students. That study confirmed the findings of Chetty (2014) that there was potential for the development of the teaching and learning environment through thoughtful use of different technologies. That study showed that the teaching and learning environment could be facilitated by proper planning and implementation using MOODLE as a platform (Maharaj, Brijlall & Narain, 2015). For these to happen the following should be focused on: (1) a user friendly module template should be in place; (2) the module teachers should exploit the use of the administration facilities that are available to get an insight into student usage and what they need to be advised on by using the news forum facility or the notices section; (3) the lecture information section requires that the lecturer puts the relevant material online timeously and the students interact timeously with the materials provided; (4) the diagnostics section which comprises of quizzes used be regularly used by students to prepare for their formal tests and examinations; (5) the module teachers should also inform their tutors of trends that they observe from the use of the administrative facilities that are available, so that the tutors could be aware of emerging trends and be informed of these when they oversee the tutorial sessions. That study reported on in this section of this chapter indicates that these five focus points could lead to increased student interaction with the material to be student and, hence learning.

It was recommended that mathematics’ lecturers put in place a user-friendly online module template for their relevant modules. This is the first step to facilitate blended learning in the context of large class environments. The diagnostics quizzes should form an integral part of the online materials provided to students. Then the administrative facilities that MOODLE provides should be used to monitor and plan for further student engagement with the teaching and learning materials, provided online. Since the use of an online system to promote teaching and learning requires a change in mind-set both of those the teaching team and the students, a successful implementation requires that both should in the loop regarding what is required of them. For this to happen, someone in the teaching team should oversee the planning and communication of the necessary e-learning materials to the teaching team and the relevant students.

**Application of LMS with university Engineering students**

The assimilation of enriched technological knowledge and communication into mainstream mathematics has become a crucial issue permeating education institutions. Brijlall and Ally (2020) reported on a study in which they focused on use of technology by undergraduate students pursuing mathematics at the undergraduate level. The study was a mixed mode case exploring mathematical misconceptions which created conflicts when engineering students (n=172) worked with online diagnostic assessments. These online diagnostic assessments were placed on the learner management system (LMS). The topics covered were fractions, logarithms, and factorization. That exploration was carried out at a South African university of technology. Written responses to the online diagnostic assessments and data from the LMS provided the relevant data. This data was analysed. The analysis led to the following findings: 1) positive increase in the group score averages were made in all diagnostic assessments, 2) procedural efficiency was improved by increased repetition in problem-solving and 3) greater success in mathematics problem solving was noted due to improved understanding of the topics done online.

Brijlall & ally (2020) used a mixed mode approach as the research involved the capture and analysis of both qualitative and quantitative data. This combination of data was necessary address the research question. These researchers used statistical variance and inferences from the varied diagnostic assessments followed by data captured from the LMS. This comprised the quantitative aspect. For the qualitative approach the written responses of the engineering students to the assessments for the various mathematics topics were analysed. The analysis identified possible strengths and gaps I the learning of the respective mathematics concepts.

The study by Brijlall & Ally (2020) was initiated by the researchers investigating the prior knowledge required for the introduction of the new topics. This was done since the lecturers could not take for granted that the students could recall or show understanding of such prior knowledge. To attempt at investigating the prior knowledge, online diagnostic assessments were carried out. The depth of the prior knowledge and conceptual understanding of the topics were assisted by the learning opportunity afforded on the LMS.

Brijlall & Ally (2020) designed a series of quizzes, keeping in mind, the prior knowledge, and concepts necessary for further learning of the new mathematics concepts. For the basic mathematical competences suitable multiple-choice questions were designed. The alternate options for the correct solution were thoroughly investigated. The cognitive levels, length of the solutions and the distractors were brainstormed. These quizzes were placed in the LMS’s data bank. Bloom’s taxonomy guided the cognitive depth of the test items. In this way three cognitive levels were formulated and stored on the LMS. To make a positive pedagogical impact as an alternate strategy to the traditional teaching and learning of mathematics the researchers considered the pacing, timing, and sequencing of the quizzes. Table 1 (adapted from Brijlall & Ally, 2020) illustrates the information of the diagnostic quizzes for three pre-calculus tests. This table presents the information in terms of the number of days the tests were open, the topics involved, the number of questions per test, the number of quizzes per page and the number of attempts made by the participating engineering students.

Table 1: Pre-Calculus Diagnostic Quiz Test feature information (Brijlall & Ally, 2020)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Quiz | Days open | Questions per level (L). | Time limit  (min) | No. of Attempts | Question layout |
| Factorisation | 5 | L1 – 10  L2 – 3  L3 -2  Tot - 15 | 30 | 3 | Shuffled Randomly  Deferred Feedback  Shuffle within questions |
| Algebraic fractions | 11 | L1 – 5  L2 – 4  L3 - 1  Tot -10 | 40 | 3 |
| Logarithms | 11 | L1 – 10  L2 - 10  Tot–20 | 45 | 3 |

N.B. Tot – indicates the total number of questions in the quiz test.

For grading purposes, the researchers selected the highest attempt. To prevent possibilities of dishonesty or cheating, students were confronted with different questions per quiz. This was done as the LMS had mechanisms which could randomly select and make positional changes to the questions.

When students were interviewed, they indicated certain challenges experienced during their online learning. Some students complained about their heavy learning workload as they were registered for many other courses too. There were some personal issues raised by some students. To overcome these challenges, the researchers varied the test duration. This time duration considered the number of questions per quiz and the level of difficulty of the test items. The longest time of forty-five minutes was allotted to the many level 1 and level 2 questions in the logarithmic quiz. Since one of the main intentions for exposing these students to this intervention was to assist build depth in their conceptual understanding, the students were given three attempts per quiz.

In this study, using online diagnostic tests, was found to be beneficial in that:

* A positive increase in group averages for the second and third attempts was noted.
* First year engineering students’ procedural competences were lacking This was observed from the high standard deviation for the fraction diagnostic quiz. This now informs us that we should take cognizance of this when engaging with future pedagogy.
* More consolidation of the first-year engineering students’ procedural proficiency was observed. This was a consequence of the greater repetition which students were afforded during the online activity.

Brijlall & Ally (2020) found that engineering students displayed greater success in problem solving in calculus topics. This they attributed to the strengthening of the student procedural proficiency when engaging with the quizzes on the LMS. When dealing with a calculus question, the researchers observed the students’ demonstrating a technique learnt when dealing with fractions. This was done earlier with the students in the online quizzes. Thus, the researchers concluded that online diagnostic testing on the LMS enforced a positive impact on the student’s mathematics learning. Also, the online quizzes addressed the gaps in pre-calculus mathematics including fractions, logarithms, and algebraic fractions.

Brijlall & Ally (2020) concluded that communication technologies which supported teaching and learning is becoming a norm of the day. They added that the role of information dissemination, via the LMS, will become part of everyday learning in the future. Most education institutions are investing in academic programs that include a substantial segment for technological classroom instruction. Since mathematics is a prerequisite entry requirement for engineering careers focus must be directed to the improvement in the quality of teaching and learning of the subject. The study by Brijlall & Ally (2020) showed that online diagnostics can make a breakthrough in ensuring better student mathematical proficiency,

**Conclusion**

From the surveys of research studies on robotics and learning management systems we conclude that artificial intelligence may generally increase the efficiency of learning and teaching in education. In the case of robotics, we have found that the usage of microcontrollers gave the learning process a tangible component and allowed students to participate in hands-on activities. This practical approach made the learning process more engaging and concrete, which raised student motivation and engagement. For the students, using the microcontrollers provided a practical experience. They could view and interact with the actual hardware, including LEDs, sensors, and actuators, which made it easier for them to learn the principles of coding and circuitry. The students were able to control the microcontrollers and produce practical prototypes by using their programming skills. The learning process became more meaningful and pertinent to their interests and objectives thanks to this application of information. When using microcontrollers, students must exercise critical thinking and problem-solving skills. They needed to debug the code and fix the issue. To achieve the desired outcome, adjust. This improved my capacity for problem-solving and sparked my imagination. One study had found that there were advantages of student involvement when robotics was used and that included an increased STEM conceptual knowledge, increased interest in the study of science, engineering, and technology, increased self-efficacy in carrying out technologically based tasks, and increased use of efficient problem-solving techniques.

In the studies on learning management systems the MOODLE platform provided an interactive mean for communication between the lecturers, mathematics subject content and the students. In that study it was confirmed that there was potential for the expansion of the teaching and learning environment through innovative use of different technologies. That study showed that the teaching and learning environment could be facilitated by proper planning and implementation using MOODLE as a platform. In another LMS study researchers found that by improving the levels of procedural proficiency in the basic mathematics topics led to more success in problem solving in calculus mathematics topics. It was observed that what students had learnt via the LMS, they applied such conceptual knowledge in other topics efficiently. Thus, that study had illustrated how diagnostic testing on MOODLE enforced a positive impact filling gaps in pre-calculus mathematics (specifically factorization, algebraic fractions and logarithms) of first year engineering students.

Overall, in this chapter we surveyed studies whose findings demonstrate that AI may have an even greater impact by serving as a new general purpose “method of intervention” that can reshape our curriculum in education.

**References**

Atmatzidou, S., & Demetriadis, S. (2016). Advancing students’ computational thinking skills through educational robotics: A study on age and gender relevant differences. Robotics and Autonomous Systems, 75, 661–670.

Ally, N., & Brijlall, D. (2018). Validating a Research Instrument: Diagnostic test for first year university of technology Engineering Mathematics students. *International Journal of Teaching and Learning*. 4(1),7-15.

Bansilal, S., Brijlall, D., & Mkhwanazi, T. (2014). An exploration of the common content knowledge of high mathematics Teachers. *Perspectives in Education,* 32(1):34-50

Brijlall, D. (2014*).* Exploring the Pedagogical Content Knowledge for Teaching Probability in Middle School: A South African Case Study. *International Journal of Educational Sciences*, *7*(3): 719-726.

Brijlall, D. & Maharaj, A. (2014). Exploring support strategies for high school mathematics teachers from underachieving schools. *International Journal of Educational sciences*, *7*(1): 99-107.

Brijlall, D., & Ally, N. (2020*).* Integrating online diagnostic tests for first year engineering tests. *Eurasia Journal of Mathematics, Science and Technology Education,* 16 (10), 1-15. https://doi.org/10.29333/ejmste/8396*.*

Berland, M., & Wilensky, U. (2015). Comparing virtual and physical robotics environments for supporting complex systems and computational thinking. Journal of Science Education and Technology, 24(5), 628–647.

Chetty, D. (2014). (ICT)-enhanced teaching and learning in the college of Human Science*, University of South Africa*. *Journal of Communication*, *5(1)*: 53-62.

Cohen, L, Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). London: Routledge.

Eguchi, A. (2014a). Educational robotics for promoting 21st century skills. Journal of Automation Mobile Robotics and Intelligent Systems, 8(1), 5–11.

Eguchi, A. (2014b). Learning experience through RoboCupJunior: Promoting STEM education and 21st century skills with robotics competition. In Proceedings of Society for Information Technology & Teacher Education International Conference.

Govender R.G & Govender D.W(2023). A Using Robotics in the Learning of Computer Programming: Student Experiences Based on Experiential Learning Cyclesssociation, New Orleans, LA.

Grover, S. (2011). Robotics and engineering for middle and high school students to develop computational thinking. In annual meeting of the American Educational Research.

Ioannou, A.; Makridou, E. Exploring the potentials of educational robotics in the development of computational thinking: A summary of current research and practical proposal for future work. Educ. Inf. Technol. 2018, 23, 2531–2544. [Google Scholar] [CrossRef].

Kilpatrick, J., Swafford, J., & Findell, B. (2001). Adding It Up: Helping Children Learn Mathematics, National Research Council, ISBN: 0-309-50524-0, 480. <http://www.nap.edu/catalog/9822.html>.

Leonard, J., Buss, A., Gamboa, R., Mitchell, M., Fashola, O. S., Hubert, T., & Almughyirah, S. (2016). Using robotics and game design to enhance Children’s self-efficacy, STEM attitudes, and computational thinking skills. Journal of Science Education and Technology, 25(6), 860–876.

Maharaj, A, Brijlall, D. & Narain, O.K. (2015). Improving proficiency in Mathematics through Website-based Tasks: A case of basic algebra. *International Journal of Educational Sciences*, 8(2), 369-386.

Nugent, G.; Barker, B.; Grandgenett, N.; Adamchuk, V. The use of digital manipulatives in K-12: Robotics, GPS/GIS and programming. In Proceedings of the 39th IEEE Frontiers in Education Conference, San Antonio, TX, USA, 18–21 October 2009. [Google Scholar] [CrossRef]

Penmetcha, M. R. (2012). Exploring the effectiveness of robotics as a vehicle for computational thinking (Doctoral dissertation, Purdue University).