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Research Article

Exploring technology acceptance: Teachers' perspectives on robotics in teaching and learning in the UAE

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ABSTRACT

It is becoming increasingly vital for the next generation of students to acquire problem-solving, critical thinking, and collaborative skills for them to be successful in the 21st century. The use of technology greatly bolsters the integration of these skills. Robotics, one of the many emerging arrays of technologies, presents learners with challenges and opportunities for developing innovative ideas, critical thinking, and higher-order thinking skills. As a result, the Ministry of Education in Dubai realized these potentials and took an essential step in the form of the distribution of Lego Mindstorms Education kits to schools with the goal of encouraging teachers to use these kits in their classrooms. This research study aimed to investigate teachers' perceptions of a training on Lego Mindstorms in terms of content, methodology, activities, and recommendations. In addition, the study investigated how teachers perceived Lego Mindstorms based on TAM model. A total of 59 high school (cycle 2) teachers participated in the current study. The data from the teachers were collected using both quantitative and qualitative approaches. Data analysis consists of descriptive statistics and thematic analysis. Teachers showed positive perceptions of robotics integration, emphasizing its potential to enhance teaching and learning. Their willingness to learn and adapt, combined with their recommendations for enhanced training methods, highlights the importance of continuous professional development for effective robotics integration. Teachers expressed the need for more practical training, hands-on activities, and a balance between theoretical and practical aspects. A positive correlation between perceived learning usefulness, perceived teaching usefulness, perceived ease of use, attitudes, and teachers' intention to use Lego Mindstorms in their future teaching was found.

Keywords: robotics, TAM model, teaching usefulness, learning usefulness, behavioral intentions

INTRODUCTION

Studies in the field of robotics have shown that using robotics in the classroom provides students with a real-world project-based framework that supports not only the interdisciplinary study of science, technology, engineering, and mathematics (STEM), but also the interdisciplinary study of other disciplines such as computer coding and computational thinking (CT) skills (Ching et al., 2019; Hussin et al., 2019; Janke et al., 2022; Plaza et al., 2019). CT idea was first put forth by Wing (2006), who described it as a set of skills that "involves solving problems, building systems, and understanding human behavior, by relying on the core notions of computer science." (p. 33). Similar to the 3Rs in reading, writing, and arithmetic, Wing (2006) refers to CT skills as mental abilities related to computing and computers (Aho, 2012; Barr & Stephenson, 2011; Grover & Pea, 2013). Wing (2006) claimed that CT skills that are used in computer science can be integrated and benefit students in all disciplines.

Robotics provide students with opportunities to develop their CT skills, engage in active learning, collaborate in solving problems, and think critically and creatively. According to Papert's (1980) constructionism and Piaget's (1954) constructivism, students learn deeply when they are actively creating knowledge by participating in projects within a learning community. A study by Williams et al. (2010) indicated that learning with robotics improved students' learning as well as 21st-century skills such as critical and creative thinking, decision-making, collaboration, and research skills. Their results were confirmed by many other studies (Benitti, 2012; Negrini & Giang, 2019). Leonard et al. (2016) integrated robotics and games in a project-based platform to develop CT skills in middle school students. Findings suggested that students who participated in robotics project-based activities scored higher than those who were not exposed to this method of instruction.

In addition, robotics combines a variety of pedagogical approaches and theories, including project-based learning, real-world problems, constructivism, and collaboration (Morgan, 2019; Petraki & Herath, 2022; Zadok, 2020). Therefore, it is regarded as an effective approach in teaching since it makes theoretical concepts more tangible and accessible to students (Anwar et al., 2019; Bertel et al., 2019; Nugent et al., 2019). Many studies showed that students' performance in science, math, and/or STEM knowledge have improved by integrating robotics in teaching and learning (Baek et al., 2019; Chiang et al., 2022). Moreover, research studies in robotics suggested that using robotics in K-12 classrooms improve students' interest and career attitude toward STEM. According to Hrastinski et al. (2019), robotics is an emerging technology that will revolutionize society. The development and application of robotics will have a major impact on how people learn and work in the near future. This is why the educational systems today need to prepare students for future jobs that do not even exist yet (World Bank, 2019). A recent estimate from World Economic Forum (2018) suggests that in the near future, intelligent machines and algorithms will create 58 million new jobs. Students today must be equipped with certain skills, including creative and critical thinking, problem-solving, metacognition skills, etc. to be able to contribute to society (Touretzky et al., 2019).

Despite the potential of integrating robotics in teaching and learning, this integration has not yet been fully explored in schools, especially in the United Arab Emirates (UAE). Furthermore, the preliminary literature review seems to indicate that, to date, there is limited evidence of research been conducted in the UAE context. Most of the UAE studies related to robotics focused on the integration of robots as assistants in the classrooms (Alhashmi et al., 2021; Mubin et al., 2019). Only few studies (e.g., Afari & Myint, 2017; AlQarzaie & AlEnezi, 2022) addressed the integration of robotics into the UAE classrooms by either discussing the country's robotics integration initiatives without researching this integration or by researching the perspectives of senior leaders in the educational sector about the integration of robotics.

In addition, many research studies worldwide have primarily tried to understand teachers' perspective on integrating robotics into their teaching and learning. However, a noticeable gap exists when it comes to a wholistic understanding of teachers' perspectives. Many studies either focused on the factors that hinder the integration (Khanlari, 2016; Papadakis et al., 2021), investigating teachers' perspectives on the integration without providing them with proper training (Chalmers, 2018) or conducting only a literature review related to the topic (Lathifah et al., 2019). This gap in research presents a significant opportunity for further exploration. Investigating teachers' attitudes, beliefs, and perceived barriers related to integrating robotics into teaching and learning can offer valuable insights. Such insights can inform the development of targeted professional development programs and support mechanisms that address teachers' specific needs and concerns. By understanding the factors that influence teachers' decisions and strategies for incorporating robotics, the UAE education stakeholders can better facilitate the integration of these technologies in a way that maximizes their educational impact.

Therefore, this research study is implemented to close this gap in the literature by investigating cycle 2 teacher's perceptions of the effectiveness of robotics training on helping them learn how to use and integrate robotics (Lego Mindstorms Education) as well as investigating their intention to use this tool in their future teaching. The Ministry of Education (MoE) in Dubai distributed Lego Mindstorms Education kits to schools to encourage teachers to integrate robotics in their classrooms. After distributing the robotics kits, MoE in Dubai planned a series of workshops to support cycle 2 teachers on how to use and integrate the Lego Mindstorms kits in their classrooms. Robotics can significantly impact teaching and learning if they are used and implemented by experienced and skilled teachers to support their students' educational needs (Usengul & Bahceci, 2020; Yang et al., 2022). It is crucial, it is crucial to provide teachers with robotics training to feel comfortable with programming and to be able to integrate robotics into learning activities (Papadakis et al., 2021; Piedade et al., 2020). The current study collaborated and coordinated with the training providers in developing the training materials and collecting data after the training. The data collected sought to answer the following research questions:

1. How did cycle 2 teachers perceive the training on Lego Mindstorms Education?
2. In what ways can the Lego Mindstorms Education training be improved to support the integration of robotics in teaching?
3. How did teachers perceive Lego Mindstorms Education in terms of ease of use, perceived teaching usefulness, perceived learning usefulness, attitudes towards the educational use of Lego Mindstorms Education, and behavioral intentions of future use?

BACKGROUND AND THEORETICAL FRAMEWORK

The fourth industrial revolution introduced several technological advancements in all facets of life, which have begun to be adopted by educational systems around the world (Kayembe & Nel, 2019). Robotics is one of these technologies that begun to be integrated into teaching and learning. Integrating robotics into teaching and learning has several benefits. Robotics is essential to the development of 21st century skills and CT skills in students (García-Peñalvo & Mendes, 2018; Masril et al., 2021). There is a growing consensus that robotics is a crucial area of research and development in the realm of education. According to the research, using robotics in the classroom encourages students to participate, helps them grasp difficult topics, and motivates them to learn (Cukurbasi & Kiyici, 2017; Menekse et al., 2017). It has been shown that the integration of robotics benefits students' academic outcomes (Witherspoon et al., 2016). Additionally, several research reviews have found that integrating robotics encourages bolsters constructivism in the classroom. Kucuk and Sisman (2017) reported that teaching with Lego increased student engagement and retention. The use of technology in the classroom, as stated by Konokman (2015), encourages students to learn, facilitates their education, and promotes greater student engagement. Robots create excitement in classrooms as an innovative technological tool, encouraging participation and fostering a learning environment for students (Karim et al., 2015).

Students of this generation have grown up with technology and are receptive to and enthusiastic about integrating technology–particularly robotics technology–into the classroom experience. Recent studies have confirmed that students respond positively to the integration of robotics into the educational setting. Students between the ages of 11 and 18 were more open to using robots and programming as a teaching tool than those between the ages of 19 and 24 (Mqawass, 2018). Another study by Ghosh (2019) found that the students had a positive attitude toward integrating robots into the classroom and demanded learning environments that make extensive use of robots. Moreover, a study by Whitehead (2011) has explored the effects of activities based on robots on mathematics classrooms aimed at middle school students. Students were given a questionnaire in the form of a Likert scale with 28 questions to answer on their views and interests in technology, engineering, and mathematics. After implementing collaborative robotic activities, the researchers noticed an increase in students' interests in technology, engineering, and mathematics as well as improvement in the students' attitudes toward these subjects.

In addition to investigating students' perceptions related to the use of robotics, a deeper examination of teachers' acceptance of technology is crucial, as the integration of technology, particularly robotics, into the classroom cannot occur if teachers resist this integration (Masril et al., 2021). Research in behavioral and social sciences provides the theoretical frameworks necessary to comprehend the widespread adoption of technological tools. The theory of reasoned action (TRA) was developed by Ajzen and Fishbein (1977) and held that actions can be accurately anticipated from their corresponding intents. In a similar vein, one can anticipate a person's behavior based on their thoughts and feelings about it. Ajzen's (1991) theory of planned behavior (TPB) expanded upon the TRA model by introducing a new component called perceived behavior control. People's confidence in their own abilities to perform a given behavior is what is called "perceived behavior control." Once more, Davis (1993) adapted TRA model to TAM (Technology Acceptance Model). TAM is predicated on the idea that the behavioral intention to use a specific technology is a significant component that can lead to the actual use of such technology.

TAM was originally developed out of research in the field of social cognitive theory and postulated that the intention to use a particular technological tool or innovation is determined in large part by attitudes toward using that tool (Davis, 1989; Davis & Venkatesh, 1995; Davis et al., 1989). Additionally, according to Davis (1989), there are two significant attitudinal antecedents: perceived usefulness and perceived ease of use. Since its first use in 1989, numerous researchers have proposed extensions to the model, including additional attitudinal antecedents in an effort to make the model more explanatory, accounting for more of the factors that can influence attitudes toward using technology (Ku, 2009; Rashed, 2001; Siegel, 2008).

The model has been tested in various contexts and technologies in the past and found to be robust and highly valid (King & He, 2006; Venkatesh et al., 2003). In educational contexts, TAM has been used in numerous empirical studies in a wide variety of institutional contexts (Ku, 2009; Parkman et al., 2018) as the most used acceptance theory. In this study, TAM is used as a theoretical lens in exploring the interrelationships between perceived ease of use, perceived usefulness, attitudes toward robotics and behavioral intentions to the educational use of robotics. This study focused on the following variables: perceived ease of use, perceived learning usefulness, perceived teaching usefulness, attitude, and intention for future use to find out the relative degree to which these variables inhibit or contribute to teachers' engagement with robotics in the classroom environment.

Teachers' perceptions, attitudes, and technological competencies are seen as crucial factors of technology acceptance. Perception denotes the cognitive beliefs, perspectives, affective attitude, preferences, and level of comprehension of a topic, subject, or phenomenon (Brown et al., 2019). Teachers' integration of robotics will be greatly influenced by their perceptions of robotics' usefulness for teaching and learning (Ogegbo & Ramnarain, 2022). Teachers' perceptions are affected by a number of variables, including their level of technical competence, professional development opportunities, the practicality of the implementation in the classroom context, and institutional policies. Therefore, it is crucial to provide teachers with the knowledge, skills and tools needed to successfully integrate robotics into the classroom (Yadav et al., 2018). Lack of access to training and support for teachers may make them wary of implementing new technologies in the classroom (Nath, 2019). Teachers' perceptions of emerging technologies' usefulness and ease of use may pose a possible obstacle (Baskin & Williams, 2006; Schoonenboom, 2014).

Although numerous studies have investigated teachers' perceptions of integrating technology into teaching and learning, few have focused on robotics integration. Teacher perceptions, intended use, and concerns regarding robotics integration in science education were investigated in a study by Ogegbo and Ramnarain (2022). They found that science teachers view robotics integration as a useful tool that can encourage students' data management and problem-solving skills, particularly when breaking down complex problems into researchable ones. The results also showed that teachers intend to integrate robotics into their teaching. However, teachers voiced reservations about integrating robotics into science classes, citing a need for more practical and contextual ideas on strategically integrating robotics in their daily lessons. Similar results were found in a study undertaken by Tang et al. (2020) to explore the perceived advantages and disadvantages of integrating instructional robotics by university instructors. Positive attitudes were observed among instructors concerning the integration of robots into education. Teachers argued that robotics might be integrated using a variety of pedagogical approaches, including demonstrations and hands-on instruction. Based on the findings, a systematic and supportive approach involving administrators and practitioners is suggested to enable the integration of robotics into teaching and learning. Administrators might, for instance, provide follow-up services, organize training seminars, and support groups for instructors, and make technology support readily available. Kim et al. (2014) administered a survey to 116 Korean educators with recent experience in using robotics in the classroom, inquiring about their perspectives on the possible use of this technology. The results indicated that the teachers deemed this technology suitable for usage beginning in the fifth grade and applicable to nearly all subject areas.

Konokman and Cukurbasi (2019) studied the effects of Lego robotics instructional techniques on teachers' attitudes and perceptions of technology-supported instruction. Before designing Lego robotics instructional methods, prospective teachers showed resistance behavior. They complained, broke down a lesson, participated unwillingly, accused the instructor, etc. After designing a robot and participating in Lego robotics teaching practices, prospective science teachers had positive perspectives on technology-supported instruction. Another study found that instructors' attitudes, experience, and skills in using technology influence their early adoption of technology and future computer use (Chalmers, 2018).

CONTEXT OF THE STUDY

The research project was a collaboration between the Emirates College for Advanced Education and the Ministry of Education (MoE) in the UAE. The training was conducted by professionals from Lego Mindstorms that provided the training to the teachers. However, several meetings have been held in collaboration with the company to evaluate their methodology and materials used in the training and provide recommendations. Before implementing the study, ethical approval from the institutional IRB and MoE was obtained. The participants were 59 cycle 2 teachers in AlSharjah and Ras Al Khaimah Emirates who volunteered to participate in the study. All cycle 2 teachers (n=59) who participated in the training gave their consent to participate in the project. All teachers participated in a two-day face-to-face Lego Mindstorms Education workshop. Teachers were divided into two separate groups. Each group participated in the training at a different site within the UAE. Teachers were instructed to bring their Lego Mindstorms Education kits to the workshop and use them to complete the training activities. Each kit contains a variety of hardware components, including intelligent brick, sensors, and motors. In addition to the Lego kit, the software includes a complete graphic programming language, data logging, multimedia tutorials, and lesson plans. There are detailed instructions and programming tutorials for a variety of projects that serve as templates for student experimentation.

As seen in **Table 1**, the first day of training focused on introducing participants to the fundamentals of the robot educator. On day two, teachers worked on more complex activities and had in-depth discussions about integrating robots into the classroom.

The four Cs framework (connect, construct, contemplate, and continue) was the theoretical underpinning of the instructional design of the training program. Flow and collaborative work are crucial to the success of the four Cs concept. According to the 2013 guidebook for Lego Mindstorms:

1. Connect–individuals are presented with an activity or challenge that invites them to seek solutions for a challenge or a problem.
2. Construct–this involves building activity or constructing artifacts.
3. Contemplate–in this stage, individuals consider what they have learned and share it with others.
4. Continue–An activity is completed with a new activity that expands on what was learned in the prior activity.

During the training, the trainer used the software's lesson planning pathways to teach the materials and demonstrate the methods for putting together and programming the robots. Teachers then used the software, and the kit for hands-on exercises. They paired up and programmed the robots by following the software's multi-media tutorials.

Table 1. Workshop schedule

Time	Sessions	Activity
First day		
09:00 AM		Welcome and ice break
09:10 AM	Session 1	Introduction to robotics
09:20 AM		Introduction to EV3 technology–Hardware
09:35 AM		Build the training model–Driving base
10:35 AM		Break
10:45 AM	Session 2	EV3 technology–Software environment
11:00 AM		System for learning–4C methodology
11:15 AM		Program to navigate–All directions
12:15 PM		Develop a smart robot (sensors)- Part 1
12:45 PM		Lunch break + Prayer time
01:15 PM	Session 3	Develop a smart robot (sensors)–Part 2
02:30 PM		End of the day
Second day		
9:00 AM	Session 1	Welcome and hands-on revision
9:45 AM		Curriculum: Robot educator–4C methodology
10:45 AM		Break
11:00 AM	Session 2	EV3 technology–Data logging
12:00 PM		Curriculum: Design engineering projects–4C methodology
12:45 PM		Lunch break + prayer time
01:15 PM	Session 3	Curriculum opportunities, lesson plans, & 4C methodology
02:00 PM		Recap, questions, & next step

Data Collection and Analysis

Three data collection tools were implemented to collect data from the participants: two questionnaires and focus group discussions. The first questionnaire was used to gauge how the teachers' perceived the training that was conducted. The questionnaire included both closed- and open-ended questions. The closed-ended questions used a Likert scale ranging from five (strongly agree) to one (strongly disagree), with the option to circle only one answer. The questionnaire focused on five main areas:

1. demographics,
2. content of the training,
3. method and activities,
4. usefulness, and
5. recommendations.

The questionnaire was designed using the company's documentation and robotics literature. Teachers' beliefs, attitudes, and intentions to use the Lego Mindstorms in their teaching were gauged with a second questionnaire that was adapted from an instrument developed by Zacharia et al. (2015) that investigates teachers' beliefs, attitudes and intentions concerning the educational use of simulations. The questionnaire consists of 50 items. The first five items of the instrument measure perceived ease of use, the second 9 items measure perceived teaching usefulness and the third 18 items measures perceived learning usefulness. These items are followed by another nine items on the attitudes towards the educational use of Lego Mindstorms Education and the final nine items measure behavioral intentions to the educational use of Lego Mindstorms Education. Teachers are asked to indicate their agreement to the statements on a 5-point Likert scale, ranging from complete agreement to complete disagreement. The questionnaire was piloted to a sample of 100 teachers who did not participate in the training to obtain internal consistent reliability. Cronbach's alpha was computed using SPSS and the following are the reliability values for each domain: perceived ease of use (five items) with internal consistency reliability of 0.84, perceived teaching usefulness (nine items) with internal consistency reliability of 0.87, perceived learning usefulness (18 items) with internal consistency reliability of 0.80, attitudes toward the educational use of Lego Mindstorms Education (nine Items) with internal consistency reliability of 0.84, and behavioral intentions to the educational use of Lego Mindstorms Education (nine items) with internal consistency reliability of 0.83.

In addition, two focus groups were conducted to collect data related to the teachers' perception of the training. Each focus group consisted of five teachers who voluntarily agreed to participate in the focus group interviews. The focus groups were conducted face-to-face and lasted for between 45 to 60 minutes. The focus group interviews consisted of nine questions that asked the participants to give their opinion on the training and the use of robotics in teaching and learning in terms of usefulness, ease of use, attitudes, intention to use, challenges, and recommendations.

SPSS is conducted to analyze the results of the two questionnaires. A descriptive analysis was conducted. Frequency and percentages analysis were done to provide background information about the participants of the study (gender, age group, and the participant's previous experience of using Lego Mindstorms). Additionally, the Mean was obtained for the rest of the questionnaire items. A number was assigned for each of the responses to the questionnaire items (strongly agree=5, agree=4, neutral=3, disagree=2, and strongly disagree=1). Focus group responses were transcribed and analyzed using a thematic analysis approach. The transcripts were read, coded, and information was assigned to the respective codes. Through reading the coded information, themes emerged. Two researchers individually read the answers to the focus group questions and created a list of codes. The two lists of codes were compared, and a final list was created. The answers and the codes were uploaded to WebQDA software to analyze the answer. This software provided a deeper analysis of the responses, which assisted in understanding the data. Multiple analysis methods were employed, including coding, word search, and text search.

RESULTS

The sample consisted of 59 teachers, 27 (45.8%) of whom were females and 32 (54.2%) were males. Slightly more than half (54.5%) of the sample were between the ages of 31 and 35 years, 34.5% were between the ages of 36 and 45 years, 5.5% were between the ages of 26 and 30 years, 3.6% were over 45-year-old, and only 1.8% were between the ages of 20 and 25 years. Regarding teaching experience, most of the participants (43.6%) had a teaching experience between 11 and 15 years, about 27.3% of them taught more than 15 years, 20% of them had a teaching experience between 6 and 10 years, and 9.1% of them taught between zero and five years. In addition, a relatively large proportion of participants (83.6%) stated that they used computers during teaching, while only 16.4 did not use computers during teaching. Only 27.6% used Lego Mindstorms Education software in their teaching, and the majority 72.4 did not use it.

How Did the Teachers Perceive the Training on Lego Mindstorms Education?

Table 2, **Table 3**, and **Table 4** show the mean of each item of the teachers' training perception questionnaire. It shows that there is a positive tendency toward the training. Almost all the items have a mean of mostly above four, which indicates a strong agreement with the questionnaire items which indicates a positive attitude. The results showed that the time allocated to the training (mean [M]=3.51) tended to be not sufficient for the training. The questionnaire items regarding the trainers showed positive responses from the participants. Most of the participants strongly agreed that the trainer was knowledgeable about the training topics and that he was well prepared.

Table 2. Means & standard deviations for the teachers' perception concerning the content of the training

Content of the training	n	M	SD
The objectives of the training were clearly explained	57	4.67	0.48
The content of the training was well-structured and easy to follow	57	4.58	0.60
The topics covered in training were relevant to me	57	4.54	0.68
Training enabled me to become familiar with key hardware components & functions (motors & sensors)	57	4.74	0.44
I have a clear understanding of the Lego Mindstorms Software environment	57	4.44	0.60
I have a clear understanding of how to apply the 4C methodology to Lego tasks	59	3.95	0.75
The main concepts covered in training helped me complete the activities	59	4.37	0.67
Average	59	4.44	0.48

Table 3. Means & standard deviations for teachers' perception concerning methods & activities used

Methods & activities	n	M	SD
Start learning the basics of Robotics was a good start	59	4.63	0.49
Using lesson planning route helped me understand how to work with building & programming features	59	4.39	0.72
The hands-on activities organized were useful for learning how to use the software and hardware	59	4.49	0.60
The collaborative work helped me complete the activities	59	4.66	0.51
Average	59	4.54	0.48

Table 4. Means & standard deviations for teachers' perception concerning miscellaneous aspects

Miscellaneous	n	M	SD
I feel more prepared to use Lego Mindstorms Education in my teaching	59	4.36	0.74
The training is useful to my teaching	59	4.34	0.66
The trainer was well prepared	59	4.80	0.45
The trainer was knowledgeable about the topics covered in the training	59	4.85	0.36
The time allocated for the training was adequate	59	3.51	1.10
Average	59	4.37	0.44

Similar results were achieved from the qualitative data collected using two focus group discussions. Overall results indicated that teachers who attended the training had a positive attitude towards the training received on Lego Mindstorms and towards the trainer who delivered the training to them. The teachers found the training interesting, useful, trained them in the use of the robotics' kit software and hardware and provided them with creative ideas on how to integrate robotics into teaching and learning. Below are some quotes from the teachers that illustrate their positive perception of the training:

> "This training is instrumental as it gives us a complete idea about the tools and sensors. The explanation was done in an excellent way. We are exposed to new options."

> "Everything was explained in an exciting way."

> "The exercises included in the workshops gave me innovative ideas for activities that can be used in the classroom."

> "The training was useful and gave me a good idea of how to integrate robots in the classroom."

> "The training was useful, and I will use what I have learned in my classroom with my students."

> "I have learned many useful and important things that I wished for a long time to learn."

> "I have an idea about the topic, but this workshop gave us more details about how to use it in the classroom. We were just using robotics outside the classroom for projects and competitions; however, we have never used it in the classroom."

> "This workshop gave us training on how to use the robots in the classroom, how to divide the students into groups and how to create tasks to the students. The workshop is well organized, and we have learned how to structure activities to our students, we can use the same structure and tasks similar to the ones used in this workshop to integrate robots in the classroom."

In What Ways Can the Lego Mindstorms Education Training Be Improved to Support the Integration of Robotics in Teaching?

Regardless of the teachers' positive perception of the training, most of them felt that a two-day training is insufficient for them to learn and practice, and ultimately to effectively integrate robotics into their teaching and learning. This result is in line with the quantitative results as the mean of "the time allocated for the training was adequate" statement (M=3.5) reflects that the teachers were not very satisfied with the time allocated for the workshop. Most of the teachers added that this training would be more useful if it was more practical and depended more in hands-on activities (in line with the statement "I have a clear understanding of how to apply the 4C methodology in Lego tasks" from the quantitative data with a mean score of (M=3.95). The mean score of this statement reflects that the teachers agree that they developed an understanding how to apply the 4C methodology in the Lego tasks but not necessarily apply it. To continue this point, one teacher in one of the focus groups argued that the theoretical part is as important as the practical part. He asserted the theoretical foundation is a must to be able to integrate robotics into the classrooms, he said "*as it provides a framework and foundations for the hands-on activities"*. This argument during the focus group discussion was very interesting and honed the data collected during the discussion. The following are some quotes from the teachers illustrating insufficient time and practical activities:

> "The time dedicated for the practical training should be increased and there should be a follow-up from the trainer during the practical aspect of the training."

> "The theoretical part needs to be limited and focus more on the hands-on activities."

> "Time is not enough to such training workshops. We need more workshops in our schools that also engage the students in the training."

When teachers were asked about how they used robotics in the classroom before this training, all the teachers responded that they mainly used robotics for competitions and extra curricula activities, none of the teachers had integrated robotics into their teaching and learning. However, from the teachers' discussion during the focus group interviews, it was found that after attending the training, all the teachers still felt that they needed more training or resources such as videos to watch at home and learn from them.

> "I used it in auxiliary lessons with mathematics, studying areas and calculating the area by the student, and there were also morning projects, color separation, and fork left"

> "We use the Lego Mindstorms with the students but mainly, we use it for competitions and only the basics, such as moving and spinning the robot."

> "We did not have kits before and we borrowed kits from another school to enter competitions, we had to train ourselves as teachers in the use of robotics by following the catalog that comes with the kit"

> "We have never used robots in the class activities."

> "We want video examples to explain how to use it with students."

> "Because of the limited time of the training, we would like to have instructional training resources related to coding and programing that we can use to train ourselves according to our own time in school or at home."

> "This workshop is a good start, however, to better use Lego Mindstorms effectively in the classroom, we would like to have more workshops that are built on the content of this two-day workshop."

> "We need another workshop and resources that can open our eyes on different pedagogies to integrate robotics in the classroom instead of just going in one direction."

> "We want to receive intensive training on using robots in the classroom and trained more using a practical approach."

> "This training workshop alone is not enough, it needs to be expanded to train us on how to integrate robotics in different disciplines. We have learned the basics; however, we need more workshops that are more connected to the curriculum."

The teachers asserted that they need more workshops and meetings between all the teachers who attend the workshops to develop lesson plans together according to what they have learned in the workshops. In addition, the teachers felt that they can take advantage from the “training of trainee “concept to effectively disseminate the integration of robotics in the classroom among teachers and schools. The teachers suggested that a selective number of teachers undergo extensive and deep training. Then these teachers can later train other teachers in their schools and in other schools. They can be trainers, and this could be their main job, which is training teachers to integrate robotic kits and robotic programming into teaching and learning. The training of these selected teachers should not be limited to the robotics hardware and software, but it needs to be expanded to include the training on how to robotics integrated lesson plans. The teachers added that the training should also be expanded to include a follow-up observations and evaluations of the teachers in the integration of robotics into the classroom. Observation visits to evaluate the integration would be beneficial for the teachers to check if we they are effectively integrating robotics into teaching and learning.

> “The ‘training of trainers’ approach can revolutionize how we introduce robotics into classrooms. Imagine a core group of skilled teachers who receive extensive training. They can then pass on their knowledge to others, becoming dedicated trainers whose role is to facilitate the integration of robotics in various schools.”

> “A few of us should undergo intensive training in robotics - not just hardware and software, but also how to weave robotics into the curriculum. These educators can later take on the role of trainers themselves, cascading their expertise throughout the education community.”

> “To ensure effective integration, follow-up is crucial. Regular observations and evaluations can help us refine our approach. These visits would give us insights into how well we’re leveraging robotics in the classroom and help us maximize its potential.”

How Did Teachers Perceive Lego Mindstorms Education in Terms of Ease of Use, Perceived Teaching Usefulness, Perceived Learning Usefulness, Attitudes Towards the Educational Use of Lego Mindstorms Education, and Behavioral Intentions of Future Use?

The teachers perceived Lego Mindstorms Education Software as easy and simple to use, as all items were rated above 4.0 (**Table 5**).

Table 5. Means & standard deviations for teachers’ perception concerning ease of use of Lego Mindstorms Education

Ease of use	n	M	SD
Interacting with Lego Mindstorms Education is simple	54	4.02	0.79
Lego Mindstorms Education is a tool that can easily be used	54	4.06	0.71
The use of Lego Mindstorms Education is simple	54	4.00	0.78
Learning to operate Lego Mindstorms Education is easy for me	54	4.07	0.82
It is easy for me to become skillful in using Lego Mindstorms Education	54	4.28	0.66
Average	55	4.08	0.62

As presented in **Table 6**, the teachers agreed that the software is useful in teaching, where the averages of all positive items exceeded 3.70.

Table 6. Means & standard deviations for teachers’ perception concerning teaching usefulness of Lego Mindstorms Education

Teaching usefulness	n	M	SD
The Lego Mindstorms Education for a fact can help me during my teaching	55	4.00	0.75
The Lego Mindstorms Education make my teaching easier	54	3.89	0.79
The Lego Mindstorms Education provide direct experiences with phenomena	54	4.07	0.67
Working with Lego Mindstorms Education makes teaching more interesting	54	4.43	0.57
The Lego Mindstorms Education relieve teachers of routine duties	55	3.78	0.99
The Lego Mindstorms Education may improve the overall quality teaching	55	4.13	0.67
The Lego Mindstorms Education could provide unique visualizations	55	4.27	0.59
The Lego Mindstorms Education make teaching more enjoyable	55	4.38	0.65
The Lego Mindstorms Education are a useful tool for teachers	55	4.15	0.68
Average	55	4.12	0.53

Likewise, as illustrated in **Table 7**, teachers agreed that the software is useful for students' learning, where the averages of all the positive items exceeded 3.90.

Table 7. Means & standard deviations for teachers' perception concerning learning usefulness of Lego Mindstorms Education

Learning usefulness	n	M	SD
The use of Lego Mindstorms Education helps students acquire skills	55	4.49	0.54
Lego Mindstorms Education enhance the understanding of complex concepts	55	4.31	0.57
The use of Lego Mindstorms Education enhances conceptual understanding	55	4.35	0.58
Lego Mindstorms Education can support student group working	53	4.49	0.58
The use of Lego Mindstorms Education promotes the use of learning strategies (e.g., problem solving)	55	4.47	0.57
Lego Mindstorms Education stimulate students' creativity	54	4.56	0.50
Use of Lego Mindstorms Education provides a better learning experience to students than a traditional mode of instruction	55	4.51	0.54
The use of Lego Mindstorms Education helps students to give better explanations	55	4.42	0.57
Lego Mindstorms Education actively engage students during a learning activity	55	4.44	0.57
The use of Lego Mindstorms Education increases interest towards learning	55	4.38	0.71
The use of Lego Mindstorms Education promotes the active participation of all students	55	4.24	0.77
The use of Lego Mindstorms Education gives the opportunity to manipulate all variables associated with the phenomenon under study	55	4.04	0.77
The use of Lego Mindstorms Education accommodates all students' different needs	55	3.98	0.73
Lego Mindstorms Education makes presentation of all concepts (both real & reified) "observable" to students	54	4.20	0.66
Lego Mindstorms Education help students to self-regulate their own learning	54	4.06	0.71
Lego Mindstorms Education improve students' achievement	55	3.93	0.77
The use of Lego Mindstorms Education promotes students' problem-solving skills	55	4.18	0.67
The use of Lego Mindstorms Education develops students' critical thinking	55	4.33	0.58
Average	55	4.30	0.48

Table 8 presents teachers' attitudes towards the educational use of the software. The results show that teachers had a positive attitude towards educational use of the software, where the overall average of the nine items is 3.82.

Table 8. Means & standard deviations for teachers' attitudes towards educational use of Lego Mindstorms Education

Attitudes	n	M	SD
Lego Mindstorms Education confuses me	55	2.44	1.05
I like using Lego Mindstorms Education in my teaching	55	3.89	0.71
I feel intimidated when I have to use Lego Mindstorms Education	55	2.29	1.10
The use of Lego Mindstorms Education is boring	55	2.04	0.90
The use of Lego Mindstorms Education disappoints me	55	2.00	0.90
The use of Lego Mindstorms Education wares me out	55	2.25	0.95
The use of Lego Mindstorms Education excites me	54	3.89	0.92
The use of Lego Mindstorms Education interests me a little	54	2.50	1.02
Working with Lego Mindstorms Education makes my teaching enjoyable	55	4.09	0.80
Average	55	3.82	0.68

As shown in **Table 9** generally, the teachers intend to learn more about the software and use it in teaching as indicates by the overall average of the behavioral intentions (3.96). Moreover, the teachers were neutral towards the item "I will use Lego Mindstorms Education as little as possible in my teaching," which has a mean of 3.20.

Table 9. Means & standard deviations for teachers' behavioral intentions to educational use of Lego Mindstorms Education

Behavioral intentions	n	M	SD
I will try to learn anything that relates to Lego Mindstorms Education and their educational use	54	4.15	0.74
I would like to participate in seminars/courses that focus on educational use of Lego Mindstorms Education	54	4.17	0.93
I would like to take Lego Mindstorms Education courses	53	3.98	1.05
I will pursuit to participate in courses of other teachers which use Lego Mindstorms Education during their teaching	54	4.06	1.00
I would like to be informed on recent developments in the educational use of Lego Mindstorms Education	54	4.17	0.91
I will teach courses that favor the use of Lego Mindstorms Education	53	3.91	0.93
I will use Lego Mindstorms Education as little as possible in my teaching	54	3.20	1.19
I intend to use Lego Mindstorms Education in my teaching	54	4.07	0.91
Average	54	3.96	0.76

Table 10 shows a significant positive correlation among all the domains of TAM survey (ease of use, teaching usefulness, learning usefulness, attitudes, and behavioral intentions).

Table 10. Means, standard deviations, & correlations with confidence intervals

Variable	M	SD	1	2	3	4
Ease of use	4.08	0.62				
Teaching usefulness	4.12	0.53	0.46* [0.23, 0.65]			
Learning usefulness	4.30	0.48	0.42* [0.18, 0.62]	0.87* [0.79, 0.92]		
Attitudes	3.82	0.68	0.29* [0.02, 0.51]	0.68* [0.51, 0.80]	0.69* [0.52, 0.81]	
Behavioral intentions	3.96	0.76	0.37* [0.11, 0.58]	0.76* [0.62, 0.85]	0.69* [0.51, 0.81]	0.68* [0.50, 0.80]

Note. Values in square brackets indicate 95% confidence interval for each correlation & * indicates $p<0.05$

Teaching and learning usefulness

In the focus group, all teachers agreed that the use of robotics in the classroom and integrating it within the teaching of different disciplines or use it in STEM lessons will help to develop students' 21st century skills, provide a practical and interesting way to teach, link the taught concepts to real life, and connect the schools to the community. Some of the quotes in this regard are listed below:

> "The use of robotics in the classroom will help the students solve real-life problems in a very practical and interesting way"

> "Implementing robotics in teaching and learning will connect the school with the community life"

> "When robotics is integrated in all disciplines and becoming part of the curriculum, it will serve the teachers and help them in the teaching and learning process."

> "The robot in the classroom enhances students' thinking, exploration skills, creative thinking, and innovation."

> "I have learned from this workshop that the integration of robotics is not limited to a specific discipline but can be implemented in all disciplines. This is very useful for all teachers from different disciplines to collaborate in implementing STEM projects with the students."

Ease of use

All the teachers agreed that the use of robotics software and hardware is easy, and it is not complicated as they thought before attending the training. They asserted that the hardware is easy to assemble by using the instructions of the accompanying catalog. They added that the use of the programming software is not sophisticated, and many aspects are easy to learn and can be accomplished with more practice and with using the right resources to learn. Below are some quotes from the teachers' focus group discussions:

> "The use of Lego Mindstorms is easy and interesting."

> "I always thought that using robotics is very complicated, but now I see that the hardware and software is easy to deal with."

> "It is not difficult to use robotics at all with the students, I will use the same structure of the workshops with my students."

> "The instructions provided in the accompanying catalog make the assembly process a breeze. This is important as it enables us, even those with less technical experience, to confidently set up the robotics components in the classroom."

Attitude and behavioral intentions

The quantitative findings obtained from the questionnaire were corroborated by the qualitative findings gleaned from the discussion during the focus group interviews regarding participants' attitudes toward and behavioral intentions of the integration of robotics in the classroom. All of the positive items in the questionnaire that were related to attitudes and intentions had a trend toward "agree" being selected as the response. In a similar vein, the trend was toward "disagree" for all of the unfavorable items, as shown in **Table 8** and **Table 9**. The teachers all concluded that learning about robotics was not only intriguing but also engaging and pleasurable. They also mentioned that they did not experience feelings of boredom or anxiety while learning about robotics. In addition, the teachers conveyed a highly upbeat and optimistic attitude toward their future plans to integrate robotics into their classroom instruction. This was made abundantly clear when teachers discussed the necessity of training other teachers, when they recommended that other teachers should participate in training in order to be able to integrate robotics into their own lessons, and when they unequivocally stated that they will definitely use robotics with their own students. The following are some quotes from the focus group discussions:

> "We will recommend this training to other teachers to be able to use robotics into the classroom."

> "I advise all my colleagues to attend such workshop if they had the chance, specifically, the math and science teachers. The workshop will encourage the teachers to use the robotics in their classrooms."

> "I recommend having all the robotics kits on Wheels and the teacher can borrow the cart whenever they planned a lesson that integrates robotics."

> "I will use the robot in teaching because it develops students' creative thinking and moves away from the traditional curriculum."

> "I am myself planning to conduct a workshop in my school for the teachers to train them on how to integrate robotics into their lesson, I want the teacher to benefit and learn from what I have learned."

> "Teachers should collaborate in creating lessons based on the integration of robotics."

> "The training changed my thinking about the way I teach, and I will change my way of teaching with the use of robotics."

> "I really enjoyed learning and using robotics in this workshop."

> "I am more confident now to use robotics in my classroom with my students."

> "While learning about robotics, I did not feel the time as it was enjoyable and fun dealing with robotics."

> "I am very excited and cannot wait to use robotics with my students."

DISCUSSION AND RECOMMENDATIONS

This study explored cycle 2 teachers' perceptions of training on Lego Mindstorms in terms of content, methodology, activities, and recommendations. It also explored teachers' perceptions and intentions to use Lego Mindstorms in their classrooms based on TAM model (perceived ease of use, teaching usefulness, learning usefulness, attitudes, and behavioral intentions).

How Did the Teachers Perceive the Training on Lego Mindstorms Education?

Regarding how teachers perceived the training on Lego Mindstorms Education, quantitative results suggested teachers' positive attitude towards the training (Tables 2-4), corroborated by the qualitative data. As seen in **Table 1**, the two-day training moved teachers from introductory to hands-on activities with the software and robotics' kit. Though they felt more prepared to use Lego in their teaching after the training (**Table 4**), teachers tended to agree (**Table 4**) that the time allocated for the training was not enough. Qualitative comments further supported this finding that more time was needed to engage them in hands-on activities. Given that 72.4% of the teachers have never used Lego Mindstorms before, a two-day training may not be enough for them to feel competent to work with the software kit and integrate in the lessons. Others have reported similar findings (Masril et al., 2021; Ogegbo & Ramnarain, 2022). For example, Masril et al. (2021) reported that the trainer could not provide more practical examples and hands-on activities to trainees due to a lack of time.

In What Ways Can the Lego Mindstorms Education Training Be Improved to Support the Integration of Robotics in Teaching?

A closer analysis of the qualitative comments suggests that the teachers may benefit from participating in a follow-up training and having access to learning resources to support their learning. To provide more situated training, teachers may benefit from participating in an ongoing community of practice (COP) in their schools and across schools to share experiences and challenges related to integrating robotics in their lessons, learning from each other and sharing samples of lesson plans that integrate robotics. COP, as noted by Mury et al. (2022, p. 9), can help support teachers in implementing robotics activities and close "the gap between teachers' capacity to use technology and their actual use of it." Moreover, as qualitative data suggested in the current study, those selective number of teachers who would receive training on Lego Mindstorms could share their experience with peers in COP. These same teachers could observe classes and discuss their notes and recommendations with teachers. Khanlari (2016), for example, reported that the implementation of robotics in lessons needs to be accompanied, in this case, by expert teacher assistants. The teachers in the current study may also benefit from engaging in collaborative action research to plan, implement and evaluate the impact of robotics on teaching and learning and then discuss further improvements. In sum, while the teachers appreciated the initial training provided to them, the Ministry of Education (MoE) may need to consider that the provision of other learning strategies such as COP would be necessary to support teachers to use and integrate robotics in their teaching more effectively. In addition, to be more relevant, the training should be more connected to teachers' practice in the classroom as suggested by one participant "we need more workshops that are more connected to the curriculum." In this regard, teachers should use their lesson plans used in schools to integrate robotics. This will make the training more meaningful for them.

How Did Teachers Perceive Lego Mindstorms Education in Terms of Ease of Use, Perceived Teaching Usefulness, Perceived Learning Usefulness, Attitudes Towards the Educational Use of Lego Mindstorms Education, and Behavioral Intentions of Future Use?

Despite the perceived limited training time and opportunities to engage in practical activities, findings revealed positive teachers' perceptions and attitudes towards Lego Mindstorms based on TAM Model. In the same vein, overall results by Zacharia et al. (2015) showed that teachers who attended the training demonstrated positive attitudes towards the use, usefulness of the software in teaching and learning and intention to use the software in their future teaching. In the current study, though teachers need more practice, they perceived the Lego Mindstorms as easy to understand and operate (**Table 5**), which is complemented by qualitative data. This result is consistent with previous research indicating that educational robotics improved teacher attitudes because it was simple to use, easy, fun, and engaging to assemble the robot as well as programming it (Bell & Vahrenhold, 2018; Brackmann et al., 2017; Tsukamoto et al., 2015). However, this finding does not align with some studies, where teachers expressed concerns about programming being too difficult (Mannila et al., 2014; Tundjungsari, 2016; Psycharis & Kallia, 2017). This inconsistency might be because the teachers in the current study have used the block programming tools and not the textual programming tools, making it easy to program using visuals instead of text (Chiu, 2020; Garneli et al., 2019; Mladenoviet al., 2020; Weintrop & Wilensky, 2019).

Findings from the current study revealed a positive correlation between perceived learning usefulness, perceived teaching usefulness, perceived ease of use, attitudes, and teachers' intention to use Lego Mindstorms in their future teaching (**Table 10**). Previous studies (Chalmers, 2018; Han & Conti, 2020; Kim et al., 2015; Masril, 2021; Park & Kwon, 2016) indicated that attitudes towards robotics are primarily determined by teachers' intention to use it, showing that the highest positive effect was determined of attitude toward to and intention of use of robotics in the classroom by teachers compared to other variables. While in the current study teachers' intention to use robotics in their future lessons (**Table 9**) was positive (M=3.96), the two-day training might not be enough to sustain their intention with time.

Framework for Training Teachers in the Integration of Robotics in the Classrooms

Based on the findings, we propose the following framework to strengthen the training for teachers to integrate robotics in their lessons (**Figure 1**). As seen in **Figure 1**, perceptions of ease of use are impacted by the training offered, which should include follow-up training and allow enough time for learning and engagement in hands-on activities, as well as a balance between theory and practice. A needs analysis with teachers should also inform the training activities to know their background, interests, and motivation. Based on this information, those teachers who are most interested should work as champions to later offer support to peers in schools. Perceptions of usefulness are impacted by the support provided during and after the training such as providing self-paced learning resources. Participation in training, and accessing relevant learning resources and activities, as well as engagement in COP and working alongside experienced peers, impact teachers' intention to use robotics in their teaching. Ongoing participation in activities such as COP may help maintain positive attitudes toward the integration of robotics in lessons.

Future research could investigate the application of this framework to ascertain the impact of these ideas such as COP and follow-up training on teachers' perceptions and intentions to use robotics in the classroom. Studies could also conduct follow-up research to survey how the teachers who attended the training are implementing robotics into their teaching to inform future actions from stakeholders.

Despite the positive outcomes, this study has some limitations. One of the limitations is the generalizability of the findings to other contexts, given the limited sample size. The sample size was small since the training organized by MoE was the first training for the teachers and only limited number of teachers were allowed to participate in the training workshop. A bigger sample is needed to explore teachers' perceptions of the training and their intentions to use robotics in their lessons.

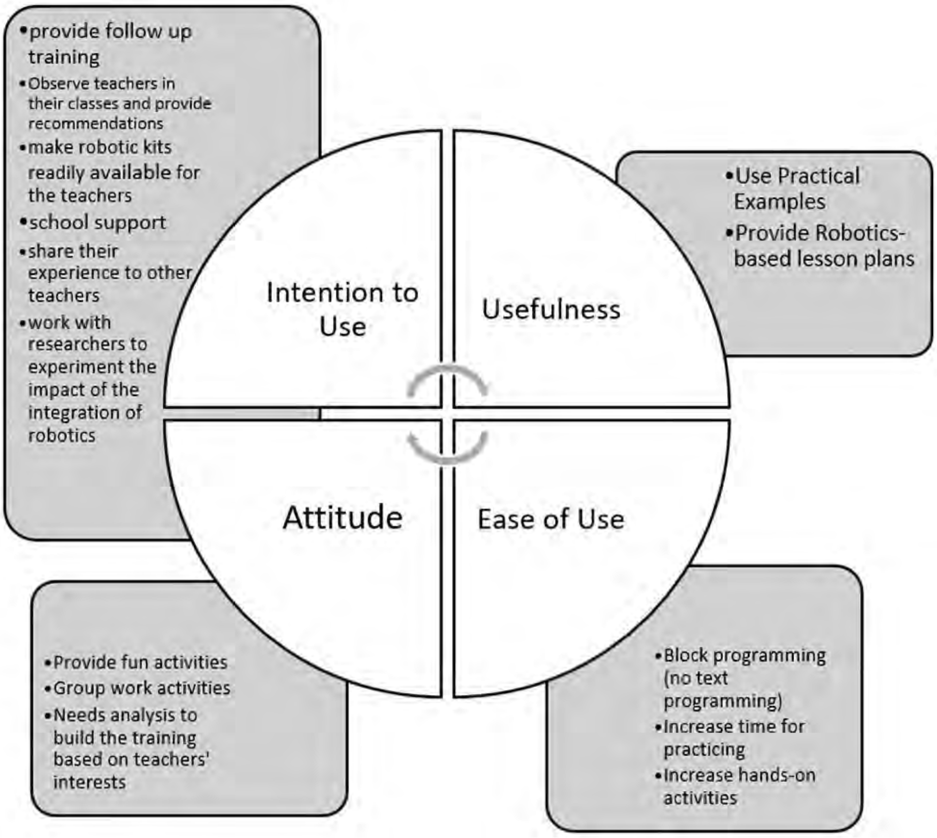

Figure 1. Training teachers in the integration of robotics in classrooms (Source: Authors)

CONCLUSIONS

This study explored cycle 2 teachers' perceptions of training received on Lego Mindstorms offered by MoE in the UAE, and their perceptions and intentions to use Lego Mindstorms in their classrooms using TAM model (perceived ease of use, perceived teaching usefulness, perceived learning usefulness, attitudes, & behavioral intentions). Results showed positive results towards the training and the trainee. Two-day training was perceived by teachers as insufficient to learn the tool and engage in more practical activities. Despite these challenges, findings revealed positive teachers' perceptions and attitudes toward Lego Mindstorms. It also found a positive correlation between perceived learning usefulness, perceived teaching usefulness, perceived ease of use, attitudes, and teachers' intention to use Lego Mindstorms in their future teaching. Based on the results, the study proposed a framework for training teachers in the integration of robotics in their lessons.

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