EXAMINING THE USE OF ROBOTS AS TEACHER ASSISTANTS IN UAE CLASSROOMS: TEACHER AND STUDENT PERSPECTIVES

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ABSTRACT

Aim/Purpose	This study sought to understand the views of both teachers and students on the usage of humanoid robots as teaching assistants in a specifically Arab context.
Background	Social robots have in recent times penetrated the educational space. Although prevalent in Asia and some Western regions, the uptake, perception and acceptance of educational robots in the Arab or Emirati region is not known.
Methodology	A total of 20 children and 5 teachers were randomly selected to comprise the sample for this study, which was a qualitative exploration executed using focus groups after an NAO robot (pronounced now) was deployed in their school for a day of revision sessions.
Contribution	Where other papers on this topic have largely been based in other countries, this paper, to our knowledge, is the first to examine the potential for the integration of educational robots in the Arab context.
Findings	The students were generally appreciative of the incorporation of humanoid robots as co-teachers, whereas the teachers were more circumspect, expressing some concerns and noting a desire to better streamline the process of bringing robots to the classroom.
Recommendations for Practitioners	We found that the malleability of the robot's voice played a pivotal role in the acceptability of the robot, and that generally students did well in smaller

	groups with the robot; teachers expressed concern that the children would become easily distracted should too many children be privy to one robot.
Recommendations for Researchers	Our results provide valuable recommendations for researchers in the area. We believe, there needs to be continued efforts in devising suitable methodological assessment tools to evaluate student and teacher attitudes in the classroom particularly in the Arab world. We also advise researchers to focus on providing adaptive behavior in the context of educational robots. There are different distinct areas that need further clarifications and study based on our review.
Impact on Society	On a wider scale, the findings of this paper have a huge implication for the educational technology as the integration of robotics in education is one of the emerging trends in the area, particularly in the UAE. This study allows to answer questions related to attitudes and perceptions of both teachers and students toward educational robots in the UAE.
Future Research	Possible avenues of research in the area include focusing on the adaptive and natural behavior of robots in disciplines other than Mathematics as a means of successfully integrating robots in the classroom.
Keywords	humanoid robots, focus groups, Emirati school, teaching, assistants, Arab culture

INTRODUCTION

Robots are currently used worldwide in most industries, including manufacturing, education, health care, defense, and space exploration, to the extent that Robotics and Artificial Intelligence experts are expecting robots to become an important tool and an essential part of our everyday life over the next few years (Graetz & Michaels, 2018). In line with this global trend, social robots are gaining prominence and popularity in the area of Education, leading to the emergence and growth of research into Educational Robots (Mubin et al., 2013). At the inception of this field, a study by Fridin and Belokopytov (2014) reported that Socially Assistive Robotics (SAR) has great potential for assisting teachers and that the successful integration and adaptation of it in preschool and elementary classrooms depends particularly on the degree to which teachers are acceptant of it.

Numerous challenges have been identified as preventing the easy and seamless deployment of (social) robots in education (Belpaeme et al., 2018; Mubin et al., 2013). Among these is the key issue of promoting the acceptance of robots both by teachers and students, particularly the former, as most interaction scenarios designed for educational robots are geared toward the student user group. Multiple studies have explored users' acceptance of robots in education and have looked at both students and teachers (Obaid et al., 2015; Serholt & Barendregt, 2014). Generally, a disparity is evident in terms of students being more positive and teachers more skeptical, and teachers' concerns tend to relate to security, privacy, and trust (Smakman & Konijn, 2019; Kennedy et al., 2016; Serholt et al., 2017). The benefits of using robots in education lie in the areas of empathy, peer-learning, and facilitation of teachers' classroom loads. However, most of these studies were conducted in specific contexts (such as in Western or Anglo- Saxon cultures) and, in some cases, with little or no actual interaction with robots (Chootongchai et al., 2019; Van Ewijk et al., 2020; Xia & LeTendre, 2020). We aim to understand Emirati teacher and student attitudes toward the use of a humanoid robot as a teaching assistant in an actual classroom within the context of a real curriculum. The rise of Artificial Intelligence and Innovation in the UAE (Halaweh, 2018) renders such an interrogation timely. Further, given the idiosyncrasies of the Arab culture when it comes to the perception of technology (Ameen

& Willis, 2015) and the lack of studies discussing the potential benefits of employing a humanoid robot as a teaching assistant in the Arab countries, it is worthwhile to study the attitudes and perceptions of both teachers and students in the UAE toward educational (social) robots. In sum, this study aimed to explore the attitudes and perceptions of both teachers and students toward educational robots as teaching assistants in Emirati schools through a series of focus group sessions with both students and teachers following educational interaction sessions with the robot. We also wanted to determine various use cases and scenarios of usage of humanoid robots in UAE classrooms from the perspective of both teachers and students. The paper is structured as follows; succeeding the introduction section is an overview of the literature in the (cultural) implications of educational robots. Thereafter, we summarize our proposed method, including the protocol, participant details and data analysis techniques. This is followed by a thematic results representation of the qualitative data emerging from the method and the paper concludes with a discussion on the results and an outlook towards the future.

LITERATURE REVIEW

A humanoid robot is defined as a robot or machine with human-like attributes (Chang et al., 2019). In general, some humanoid robots such as NAO, Akıncı, and Asimo consist of a full body, head, two arms, and two bases; however, some others such as Kompai, RollinJustin, iRobiQ, and Pebbles are built with just a partially human-like body model. Robots such as Actroid DER-2 and Saya are android robots designed to be very similar to human beings, with facial expressions and communicative functions like head and eye movements (Özdemir & Karaman, 2017). Chang et al. (2019) state that including human-like features in a robot's design functions to increase its acceptability by human users.

Humanoid robots can play the role of a catalyst and can assist students to develop contemporary fluencies including, but not limited to, computational thinking and coding skills as well as language learning (Keane et al., 2016; Keane et al., 2019). According to Keane et al. (2020), the successful implementation of emerging technology in education requires cognizance of the principals of investment on the part of those carrying out the implementation. These invested principles encourage an active community of practice (CoP) and have the capacity to empower, support, and create trust between school staff during the implementation process of humanoid robot technology which, in turn, may allow teachers and the school leaders to feel more confident about the integration of the technology into their system. Interactive technologies such as humanoids robots can also enable constructivist learning environments in scenarios where students are not otherwise able to physically interact. According to the constructivist approach, learning occurs when a student is actively engaged in the process of meaning and knowledge construction in a way that links both the mind and the body to the knowledge (Dobrosovestnova, 2018).

Interest in educational robots has increased significantly in the last couple of years (Benitti, 2012). Previous studies have also shown that robots can help students learn computer programming, science, and mathematics as well as develop their problem-solving skills (Belpaeme et al., 2018; Benitti, 2012; Mubin et al., 2013). Research demonstrates that students seem to accept the humanoid robot as an authority because of its human-like form and function, even though they are entirely aware that the utilized robot is nor a human or a real teacher (Özdemir & Karaman, 2017). A social robot tends to be perceived as an assistant to a teacher and as more of a playmate or friend to a student (Hyun et al., 2010). Employing robots to support teaching and learning at all grade levels, from secondary school to graduate level, has become an important research topic in recent years due to its implications for society at large (Ryu et al., 2008). Humanoid robots are also defined as fully embodied robots that can be utilized in both informal and formal education (Tanaka & Matsuzoe, 2012) or as embodied characters such as Pleo, the camarasaurus dinosaur (Heerink et al., 2012). Such robots have the capacity to participate in social interactions due to their ability to speak and display facial expressions. Humanoid robots have been observed as teaching assistants and helpers in various courses

(such as art and science courses) as they tend to attract and capture the concentration and interest of younger students (Tuna et al., 2019) in topics ranging from arts, sciences, mathematics and physics. Moreover, robots can also be used in the primary education system for foundational language instruction (Mubin et al., 2012). It has been demonstrated that young students perform better on post-learning examinations and produce better results when language learning occurs with the assistance of a robot than with the assistance of audiotapes and books (Altin & Pedaste, 2013). However, there are two sides to this coin; the above-mentioned approach could also have another repercussion, which is that students may (gradually) lose interest in humanoid robots if they do not interact similarly to how they expect a human teacher would interact (Serholt & Barendregt, 2014). Typically, the delineated prior work does not address longitudinal studies with educational robots embedded in the actual curriculum, Further, most interactions amongst student and robot are one on one (not group based) and any interventions or use case scenarios designed are student centered with minimal input from the teacher. We believe focusing on such endeavors can improve our understanding of the integration of humanoid robots in the classroom across all regions and cultures.

Our focus of study is also the UAE and hence Arab culture, and the impact of culture on the perception and reception of robots should not be underestimated. Preliminary research studies have already provided some evidence for the impact of cultural background, gender difference, and past experiences of real–acting robots on subjects' perceptions and attitudes toward humanoid robots (Andrist et al., 2015; Papadopoulos & Koulouglioti, 2018). For example, Bartneck et al. (2007) studied some cultural differences undergirding negative attitudes toward robots and concluded that people from online communities, who are more used to technology, tend to be more positive toward robots than other communities.

To facilitate the integration of humanoid robot technology, it is essential to understand the attitude toward robots in the Arab region. A survey-based study conducted by Mavridis et al. (2012) notes a negative response to the idea that education might ever be fully delivered by robots in the Middle East. However, Mavridis' and colleagues study (2012) also indicates that respondents from all Middle Eastern regions feel that learning through robots will be more joyful for children. According to Riek et al. (2010), the Arabic attitude toward humanoid robots overall is positive. The Gulf region's respondents were more accepting and had generally more positive views about humanoid robots than did respondents from the African regions (Morocco, Egypt, Tunisia, Sudan, and Libya). Respondents preferred humanoid robots as an assistant tool and did not want them to replace humans. The above studies, while providing a snapshot of cross-cultural research in human-robot interaction, are limited in documenting the application of educational robots in the Arab region.

The long term objective for educational robots is their commonplace usage in the classroom by students and teachers alike. In general, the expectation is that young students will most likely be able to ask humanoid robots any questions they might have, and given the enquiring student's learning profile, they will receive a customized response. However, to achieve this goal, the humanoid robots need to be progressively more human and adaptive. These frameworks need to be able to understand individuals and analyze human needs and how we think, afterward utilizing that data to associate with students effectively (Eguchi, 2014). Another challenge that this kind of technology could encounter in the classroom is that these technologies could consume a lot of teaching time compared to an ordinary teacher if they are not effectively designed. Furthermore, there is a long way to go before robots reach a level where they can effectively interact with human beings without any misunderstanding (Mubin et al., 2014). These and the other aforementioned challenges provide an interesting and multifaceted perspective on the employment of robots in UAE classrooms.

Humanoid robots could emerge as effective assistants for teachers, and this could help in two ways; firstly, their presence could serve to make teachers and administrators more supported and in turn more motivated, allowing them to concentrate on their core skills and helping them to develop ad-

vanced skills in STEM subjects. Secondly, using humanoid robots could help teachers and administrators to feel more confident and capable of delivering students' education and improving their attitudes.

METHODOLOGY

This study employed qualitative content analysis of transcripts obtained from the focus groups (Mayring, 2000) to understand teachers' and students' attitudes and perceptions towards the potential utilization of humanoid robots as teaching assistants in the classroom. Qualitative content analysis is inductive in nature as it goes beyond counting words but instead draws conclusions out of the examination of data and themes and topics. As the qualitative content analysis did not contain counts or statistical figures, the analysis was mainly focused on exploring attitudes, perceptions, feelings, and beliefs towards the humanoid robot technology.

The objective of the research project was to explore the effectiveness of the humanoid robot (NAO) as a teaching assistant. Data were collected through teacher and student focus groups (Kvale & Brinkmann, 2009), pre-test and post-test scores, and student-robot interaction video recordings. This article reports on the findings from the focus groups.

CONTEXT

The study was conducted in a government school in the city of Abu Dhabi, the capital of the United Arab Emirates (UAE). The school was established in 2006 and it follows the UAE Ministry of Education curriculum. The school aims to enable pupils to become fluent in three languages and to provide opportunities for students to demonstrate innovation using STEM subjects in a cross-curricula context. We contacted the school and found that they were interested in carrying out this project. The school principal was provided a letter relaying the approval of the Department of Education and Knowledge (ADEK's), once we had secured it. The school administrators selected grade four to participate in the study. We obtained ethical approval to conduct the study from ADEK as well as our host university. All experimental protocols and interactions described hereunder with students and teachers were ethically approved in the afore-mentioned ethical application.

PARTICIPANTS

All grade four students had some interaction with a humanoid robot during either the familiarization session or the interaction session using the robot as a teaching assistant. Thereafter, a total of 20 students participated in four focus groups and five teachers participated in two focus groups. All participating students were Emirati. Arabic was their first language and English was the medium of instruction at the school. The students were randomly selected to represent the grade four population. In addition to this, a total of five Emirati and non-Emirati foreign teachers participated in two focus groups. The same teachers were present during the familiarization session conducted among students and observed the revision process that was conducted using the robot; afterward, they were invited to join a focus group session. A consent form explaining the purpose of the research was sent to the teachers and the students' guardians. Participation was completely voluntary on the part of all participants.

SETUP AND MATERIALS

The humanoid robot, "NAO" (Gouaillier et al., 2009), was used for our research. Developed by Softbank Robotics, NAO is one of the de-facto platforms for conducting research in social robotics, human-robot interaction, and the study of educational robots (Belpaeme et al., 2018). Measuring 58 cm tall, NAO has 25 degrees of freedom and is renowned for its cute demeanor and appeal to young children. Prior to the study, the teachers selected the topic of "ordering decimals," which the students then reviewed with the robot. The lesson structure for the teaching assistants was developed in close

consultation with their class teacher, with the robot thus functioning as a proxy for the class teacher. A few weeks before the study, the students participated in familiarization session in which they were introduced to NAO and given sufficient student-robot interaction time to facilitate familiarization and give the students an opportunity to become accustomed to NAO's features.

The students received instruction on the topic of ordering decimals from their teacher. The following day, the students were randomly divided into two groups. Group A received a small-group revision session covering the same topic with the robot and Group B received a revision session with a member of the research team. The revision sessions were conducted in an isolated corner of the staff room at the school to avoid disruption. The revision sessions were based on a predefined script focusing on engagement, interactivity, and encouragement initiated by the teaching assistant in addition to an explanation of the content. Both assistants, the robot and the human, followed the script fairly strictly in order to render their processes commensurable. A group of four children interacted with the teaching assistant per session. Each group of four children was invited to sit in front of the teaching assistant and all sessions were video recorded. Just behind the teaching assistant, a Power-Point presentation was being projected, which acted as complementary content to the verbal dialogue of the teaching assistant. For example, the slides displayed content visually and through animations. Examples of the slides have been provided (see Figures 1 and 2). The teaching assistant's lesson structure was fairly linear, initially introducing the basic topic of ordering decimals and concluding with advanced exercises. A number of default responses were also programmed to enable the robot to respond to any student initiating dialogue (these responses included "great question," "great answer," "we will get to this later," etc.). An example of the conversation between the teaching assistant and a group of students is given below; this section of conversation occurred when the slide from Figure 1 was displayed on the computer.

- Teaching Assistant: 0.4 is less than 0.6. Is this TRUE or FALSE?

- Student: (wait for student(s)' response)

- Teaching Assistant: (Default response; such as Nice Try, Great Job, Better Luck next time)

- Teaching Assistant: It is TRUE because if you use the number line, you will see that 0.4 is less than 0.6

NAO was controlled, using a Wizard of Oz setup (Okita et al., 2009), by one of the researchers who was seated behind a large screen out of the view of the children (see Figure 3). A fixed protocol was followed when controlling the robot and appropriate robot behavior was generated as per the script. The same researcher was also controlling the transition of the PowerPoint slides. To replicate a real-world setting, there would be no other human present with the robot and the children. In the second review session, our team member followed the same protocol. The children did not know her prior to this session.

Figure 1: Example of an exercise from the lesson

PROCEDURE

Following these revision sessions, student and teacher focus groups (Kvale & Brinkmann, 2009) were conducted. The purpose of the student focus groups was to explore the students' perceptions about participating in revision sessions led by a humanoid robot. The questions centered around the students' experiences, including what they had learned, which aspects they had enjoyed, which aspects they had disliked, their preferences, and their interactions with the robot. The list of questions is provided (see Appendix A).

The purpose of the teacher focus groups was to explore their perceptions about the potential use of humanoid robots as teaching assistants. The advantages and disadvantages of the robotic teaching assistants, the tasks that could feasibly be delegated to a robotic teaching assistant, and the shortcomings and limitations associated with robotic teaching assistants were discussed. These face-to-face focus groups lasted around 50 minutes on average. The participants were asked at the beginning of the session about their preferred language and the sessions were carried out as per the participants' preferences. A consent form was distributed and explained, and the voluntary nature of participation was highlighted. The audio of the focus groups was recorded and transcribed in full.

Figure 2: Example of an exercise from the lesson

Figure 3: The setup of the robot's review session

DATA ANALYSIS

The focus group data were analyzed using NVivo 12 Plus. Each transcript was read and coded sentence by sentence. NVivo is a qualitative data analysis software that helps to conduct deeper analysis and discover insights and produce clearly articulated, defensible findings backed by rigorous evidence (NVivo, n.d.). Total of six transcripts were read and coded sentence by sentence (20 students participated in four focus groups and five teachers participated in two focus groups).

The process of content analysis involved the following five phases (Mayring 2000; Potter & Levine-Donnerstein, 1999):

1) *Category Development:* An initial list of categories/ nodes was created as they emerged while reading the focus groups transcripts on NVivo 12 Plus software. For example, one student said, "I am not shy to answer but I am shy to ask." This was coded in the "interaction" node. Another student said, "I like it because he is short" and this was coded in the "appearance" node. The researchers worked independently on developing the categories/ nodes to investigate the different themes. Then the thematic coding was discussed between two of the authors to resolve any discrepancies or biases.

2) *Coding System Testing:* The coding system was tested later on by coding sample text by the two researchers to check the consistency and changes has been made to the coding system wherever required.

3) *Text Coding:* After organizing the data using NVivo, the data were carefully read and assigned into categories/ nodes.

4) *Consistency Check:* This phase involved rechecking the consistency of the coding system to ensure that the transcripts of the focus groups were coded in consistent and reliable manner among the researchers.

5) *Data Analysis:* The data was read again and again and interpreted to draw valid inferences.

RESULTS

We now present a summary of the main results categorized into themes across both user groups. The students in general had high expectations from the robot. When asked about their preference, they all agreed that they preferred their revision session with NAO over a session with the teacher. The teachers were slightly more circumspect about the possibility of NAO's integration into their classrooms and raised various deficiencies and shortcomings in either the robot itself or its presentation.

THE OVERALL VIEW: "THE ROBOT CANNOT MAKE MISTAKES"

The students in general expressed that they enjoyed the revision session with the robot and that they would like to have more of these. The students were asked, "On the scale of 1-10, 1 being not so good, 10 being great, how would you rate the session?" To this, they all answered 10 with the exception of one child, who rated the session at 9.5. In terms of their learning experience, the students asserted that they gained a better understanding of mathematics, of decimals in this case, by participating in the revision session with the robot. Interestingly, the students thought that the robot could not make any mistakes because, "He is electronic and he knows a lot of things," while they thought that the teacher could make mistakes sometimes. As for the teachers, they stated that the robot was a useful tool that could assist them with a number of tasks. The teachers were certain that the robot would appeal to the children and engage them since, "they are the tech generation." The teachers perceived the robot to offer a more interactive experience than other electronic devices like iPads, which they described as providing a passive experience.

STUDENT-ROBOT INTERACTION: "IT WAS LIKE OUR FRIEND"

The participants, with the exception of one student, revealed that they didn't feel shy or hesitant to answer the robot's questions and to also ask the robot questions.

Most expressed that they might have felt shy to voice a question to the teacher but that this did not apply to the robot. A student justified this by saying that, "The robot is not a human being!" The teachers agreed that a key advantage of the robot was that even shy students would be able to answer and ask questions, especially in a small group setting. They also thought that the robot interacted very well with the children, different from other electronic devices or an iPad. It seemed that the robot's friendly and cute appearance was of considerable importance to the students. A student commented that, "His voice was nice," another student said that he liked the robot's eyes, and a third commented, "I like it because he is short." The teachers were concerned about the robot's language and considered it to be a major limitation. Since the students speak English as a second language, the teachers said that the robot's language and accent could be too complicated for them to understand. Conversely, the students indicated that it was easy to understand the robot and that it had spoken clearly. A student added, "The teacher speaks fast but the robot does not." A student in one of the sessions said, "I don't understand some people when they speak English but the robot speaks English clearly."

POSSIBLE USES: "I WANT THE ROBOT TO PLAY WITH ME"

The students perceived the robot as a friend and wished for it to be involved in social activities. They wanted the robot to sing, dance, and play with them, to be their friend. They also shared that the robot could help them to better understand mathematics through more revision sessions. While tasks like assessments, revisions, practice, etc. can be delegated to a robot, the teachers argued that the robot lacked a human sense of empathy and hence would not be able to assist in tasks that require social or emotional competency such as counseling work, hugging a child, character building, or maintaining the well-being of children.

ASSESSMENTS

Certain assessments carried out in the classroom require one-on-one time with each student. In classes of around 25 students, such interactions can take a lot of time. One teacher reported, "Like this week, we did those progress reports for the Ministry of Education … but you have to listen to each child, yeah. I think the thing is, as a teacher, after you have listened to like 5 or 6 children, it's exhausting."

Furthermore, the pen and paper tests conducted at the early grade levels do not assess students' levels accurately, as one teacher described her struggle, "We have to read the exams to the students, and I have to run between two classrooms … so I'm running to one classroom reading the question, trying to explain what to do, then running to the other classroom. There are some kids that write faster than the others and if they miss a question, they just leave it."

The teachers mentioned guided reading and formative assessments as areas with great potential for the robot's assistance. One teacher suggested, "I think it [the robot] is also really good in pre and post testing. Like to check their [the students'] prior knowledge before you even start something or like once you finish teaching something. I think that's really helpful. It actually will be great if it could be like linked to some kind of recognition so it could actually like predict and you get an average of what's going on in your classroom. Like how many students know something, I mean that will be really excellent just to keep data tracking."

DIFFERENTIATION

A key challenge here that came up among the teachers was a concern that the robot would not be able to provide differentiated instruction as per each individual student's need. A teacher described

her approach as, "I change the way that I explain each time. I don't repeat myself in the same words because, for example, if they didn't understand the first time from a smartboard I might give them cubes to play with, puzzles, and different resources not the same way. Because some students want to see and touch in order to understand." Her sentiment was that this approach could not be applied by a robot.

However, the teachers also identified areas in which robots could be utilized to aid differentiation as directed by a teacher. One teacher explained, "I don't always have time to sit with the really high students and see how far they can go. So [the robot] can be used definitely for extending towards my students … at the same time practicing with the students who are very low … just taking extra groups where I don't always have time to do it … take the extreme cases." Another teacher suggested catering for the needs of second language learners or special needs students who require plenty of practice or reinforcement. One teacher described the role of the robot in reinforcing concepts for students and guiding practice sessions. Another teacher explained how this application of the robot would work, "So doing some reading comprehension or practicing questioning with them a lot… or even just speaking … like communication. You know … because I think that sometimes it's a lot… like the pronunciation can be hard. They just need some extra practice."

THE LEARNING ENVIRONMENT: "IT IS EASY TO UNDERSTAND THE ROBOT"

The students shared that they preferred learning in small groups. They complained that in the regular classroom it was hard for them to focus because sometimes there was noise, which made it hard to listen to the teacher or to their classmates. Hence, they were happy that the revision session with the robot took place outside of the classroom and with a small number of students. The teachers also preferred for the small-group session with the robot to take place outside of the classroom, "The kids also they like the robot, so it could be a distraction in the classroom. I think it is better to take them out of the classroom to be honest with you, in smaller groups." The teachers shared that one of their main challenges was the time limitation, which did not allow them to carry out small-group instruction or one-on-one interaction with the students which, they reported, is essential for students at the kindergarten and the primary school levels. They also noted that the new curriculum was fast-paced and that they were too busy keeping up with lesson planning.

ROBOT LIMITATIONS: "THE ROBOT CAN BREAK"

Having high expectations from the robot, the students noted very few limitations when they were asked to consider them. They were primarily worried about the possibility of the robot getting broken or destroyed if there were too many students using it. One student suggested that, "the robot could explode." The teachers also worried about the vulnerability of the robot as noted in the following quote, "I think the initial challenge is that at first children won't understand that it [the robot] is a teaching aid because they generally will think it's a toy to mess around with. So I think that you need to establish a really strong … like boundaries with them … like a set of rules. So I would introduce them in my class… we do it as a whole group so that the children see how it interacts… what it does… before I start small groups. So that they learn the established boundary … and they know what is acceptable or not." The teachers were concerned about managing students' behavior and dealing with hyperactive students who would not sit down, which requires "a strong presence and a constant reminder." The teachers discussed how the robot's capacity to manage student behavior and maintain discipline would depend on how interactive it was with the students.

DISCUSSION

In general, we witnessed a certain discrepancy between the views of the Emirati students and the perspectives of their teachers regarding NAO. The students were generally accepting of and enthusiastic about interacting with robots, whereas the teachers tended to think of robots as more of a work

in progress with a number of unaddressed questions in their minds. This result is aligned with research done on the usage of educational robots in non-Arab contexts (Ahmad et al., 2016a, 2016b). In another study, students in the USA perceived NAO as a sociable agent and they generally preferred interacting with NAO to other types of study support such as those provided by teachers, adults, peers, and computer programs (Liles & Beer, 2015). We also demonstrated that the students had high expectations from NAO's intelligence as a teaching assistant, a finding that also mirrors those of prior investigations (Shin & Kim, 2007). Our results whilst in line with prior literature, showcase that the perception of humanoid robots in the classroom is perhaps independent of any cultural biases.

In our study, both students and teachers considered NAO to be engaging, friendly, and unintimidating, although this feedback must be considered in light of possible novelty effects of interacting with an advanced piece of technology like NAO (Robaczewski et al., 2020). Nevertheless, this result is also in line with previous research; in Spain, most K-12 students said that they felt comfortable interacting with the robot, and the younger ones wanted to be friends with it (Conde et al., 2016).

The ability to manipulate the robot's voice was highlighted as an important factor, which is also supported in the literature (Sandygulova & O'Hare, 2015). Both teachers and students desired rich and emotional interaction from the robot to experience a sense of empathy. Such personalized and natural interactions and the desired sense of bonding are key to the success of long-term human-robot interaction (Alves-Oliveira et al., 2016; Leite et al., 2014). The teachers were eager to utilize the robot for mundane and mechanical tasks, mirroring prior work where robots have been considered for use as exam invigilators (Mubin et al., 2020). Since our study was essentially a one-off, the role of adaptive behavior was not fully explored and hence it is very possible that the robot would become monotonous after a while if there was no natural transition in its behavior (Ahmad et al., 2019; Kanda et al., 2004). The importance of adaptive and natural behavior was indicated by both teachers and students, particularly relating to customizing its response to each child or student individually.

Both teachers and students appreciated the fact that the robot provided an opportunity for breakout sessions, which were not possible if there was only one teacher. The fragile nature of the robot was mentioned by both students and teachers, pertaining to the potential breakdown of the robot and the need for it to maintain discipline, which was similar to previous findings (Sharkey, 2016). In our study, the teachers also indicated that a humanoid might be distracting in larger classes for students and felt that focused and smaller groups would be more beneficial. A similar sentiment was expressed in some prior work conducted in Taiwan, in which Lin et al. (2009) conducted an interview-based study exploring the perceptions of robots among students in grade five. They noted positive attitudes among the majority of students toward utilizing robots in classrooms, while some of them preferred the traditional learning system and were concerned about the prospect of robots distracting them from learning. Our results not only indicate the overall positive acceptance of humanoid robots in UAE classrooms but have also identified interesting use case and scenarios of adoption. Such as, co-learner, quiz-taker and small cohort tutor. Therefore, these serve as important areas of future investigation in the area.

CONCLUSION

In this paper, we have presented a case study indicating the potential for a humanoid robot to be used as a teaching assistant. A robot called NAO was used to review a Mathematics lesson with grade 4 children in the United Arab Emirates. Our study is, to the best of our knowledge, the first in the Gulf region to explore the role of robots as teaching assistants in the classroom and is hence the main highlight of our work. Further, our study places the humanoid robot in the context of a real curriculum rather than having it teach imaginary learning content, meaning that our findings are more reliably mappable onto real-world curricula.

The major findings of this study indicated that students had high expectations from the robot in terms of interactions and abilities and they have preferred the revision session with NAO over a session with the teacher. Students have also indicated that they gained better understanding with the robot, it was easy to understand the robot language, and that they were not shy to ask or answer questions. In addition to that, students thought that the robot cannot make mistakes unlike the teacher. However, the students were concerned about the possibility of the robot getting broken, destroyed, or that it might even explode. Teachers were in general more circumspect, expressing some concerns, and noting a desire to better streamline the process of bringing robots to the classroom. The main concerns of the teachers include the robot lacking human emotion and empathy, the students' ability to understand the robot's accent, and the ability of the robot to provide differentiated instruction and to manage students' behaviors. Nevertheless, teachers have also stated that the robot was a useful tool that could assist them in the classroom and that it offered a more interactive experience than other electronic devices like iPads. Additionally, we have found that the malleability of the robot's voice played a pivotal role in the acceptability of the robot and that students generally did well in smaller groups with the robot.

On the robot-student ratio, teachers expressed concern that the children would become easily distracted should too many children be privy to one robot. We have also relayed the main findings that emerged from the focus groups we ran with the students and the teachers after the revision session, which cast an important and positive outlook on the future deployment of robot usage in Emirati classrooms. Both students and teachers were on the search for natural and adaptive behavior from the robot, such as by adapting to the students in real time. This is a continued area of interest for practitioners in the area of educational robots. However, our results must be interpreted in light of the certain bias that may have emerged due to the novelty effect of interacting with a (cute) robot as experienced by the students. Although we attempted to mitigate this by having extended interaction amongst the students and the humanoid robot, we believe saturation in perception of robot behavior is an important consideration and as a means of addressing this longitudinal studies with other humanoid robots would be worthwhile. Also, our area of investigation was specifically Mathematics learning and some of the findings may not generalize to other subjects.

Our results provide valuable recommendations for researchers in the area. This study allows to answer questions related to attitudes and perceptions of both teachers and students toward educational robots. There needs to be continued efforts in devising suitable methodological assessment tools to evaluate student and teacher attitudes in the classroom, particularly in the Arab world. We also advise researchers to focus on investigating adaptive behavior in the context of educational robots. The findings of this paper have significant implications for educational technologies as the integration of robotics in education is one of the emerging trends in the area, particularly in the UAE. Possible avenues of research in the area include focusing on the adaptive and natural behavior of robots and on student and teacher attitudes in disciplines other than Mathematics as a means of successfully integrating robots in the classroom.

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APPENDIX

Students focus groups' questions after the robot revision session

1) Did you enjoy the session with the robot?
2) What was your favorite part?
3) What do you think about it?
4) How was your experience with a robot different than with a teacher?
5) Is it hard to understand the robot or easy?
6) On the scale of (1-10, 1 being not so good, 10 being great) how would you rate the session?
7) How would you describe the experience to parent?
8) What are the things you didn't like about the robot?
9) Was the robot interacting enough?
10) Was the robot different from the iPad?
11) What are the challenges or disappointments you face in the session?
12) Do you like the robot to teach you something new or just to review lessons?
13) What are the main differences between the review lesson with the robot and with the teacher?
14) What do you think of the duration of the session, long enough or too short?
15) Do you like to have more sessions with the robot more often?
16) Is this the first time you meet a robot?
17) Would you like to meet the robot more often?
18) If the robot were to visit your school every day, what do you want him to do?
19) Does the robot make mistakes?
20) Does your teacher make mistakes?
21) Do you prefer the robot to be in the classroom or outside the classroom?
22) Were you shy or scared from the robot?
23) Will you ask the robot the same way you ask your teacher or different?

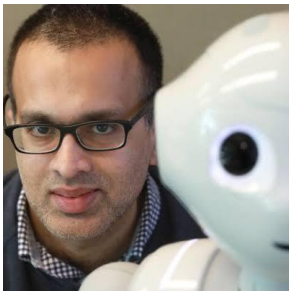Students focus groups questions after the teacher revision session

1) How was the revision session? Was it useful?
2) What do you think of the duration of the session, long enough or too short?
3) What changes would you like to suggest to the session?
4) Do you prefer the session to be conducted with the robot or with the teacher?
5) Do you think you will learn more from the robot?
6) Do you feel more comfortable with the robot or the teacher?
7) Are you shy or scared from the robot?

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