Moe the Monkey: A Fun Way to Educate Children

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ABSTRACT

This paper presents the development and usability testing of Evoke, an interactive avatar that can see, hear and respond to children in pitch-altered voice in real-time. The system uses Moe, a stylised monkey, as an interaction point between the teacher and children. Children remained fully engaged, responded more openly, and friendlier to the avatar (Moe), which was controlled by their teacher in a separate room. The user testing showed that the children listened to the character and were eager to ask questions, they grabbed and retained information given by Moe.

1. INTRODUCTION

Augmented Reality (AR) is "a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view" (Walsh, 2011). AR is different from Virtual Reality (VR), as VR offers a computer-generated virtual environment to the users but AR overlays digital information on real-world elements. AR bridges the gap between virtual and the real world, and popularly used in the visual art, commerce, archaeology, military, navigation, architecture, medical and flight training (Chang et al., 2010).

There has been growing research interest in AR application in training/education from academic researchers and industrial professionals due to its significant impact on the world economy. AR is a potentially game-changing technology, its ability to enhance reality with computer-generated sights, sounds and data, transform the way we view and interact with the world. Overall, the revenues from AR market will be over $100 billion by 2020 and the potential education market for AR will be around $300 million. Additionally, the number of AR users will grow at a healthy rate of 35% for the next few years. Currently, over 1000 companies are working in the domain of AR, and it is predicted that over 500 million AR headsets will be sold every year until 2020 (Savage, 2016).

AR can make studying a fun-filled experience. Some recent commercial surveys showed that customers value 33% more AR products than non-AR products. Emerging AR classroom applications include homework mini-lessons, book reviews, yearbooks, world wall, lab safety, deaf and hard of hearing sign language flashcards etc. (Team, 2017).

Many researchers believe that AR can strengthen students' motivation for learning new things and enhance their educational realism-based practices. There has been increasing number of research over the last few years on the adaptability of AR in education, yet the challenges of AR integration with traditional learning methods, development costs, maintenance and resistance to new technology are still there (Lee, 2012). Just like any other discipline, for technology acceptance and retention, empirical studies can act as a roadmap to investigate the potentials of AR implementation into educational settings (Asghar, Cang, & Yu, 2018).

This paper developed a real-time interactive application called Evoke, using emerging technology for an educational environment. The system created an avatar (Moe) that interacts with the audience (children). A motion capture technology was used to control the avatar to mimic teacher's movements. Moe as a teacher in schools, will encourage positive engagement, increase motivation, and increase knowledge retention in the children. Research shows that engaged students tend to be attentive, they show positive emotion and demonstrate more effort as compared to the less engaged student (Fredricks, Blumenfeld, & Paris, 2004). Connell et al. associated student engagement with positive student experience, higher grades and lesser dropouts (Connell, Spencer, & Aber, 1994). Hence, this study aims to investigate the usability and acceptability of newly developed interactive AR application for teaching school children.

This paper contains five sections. Section 2 highlights the literature relevant to this study. Section 3 describes the details of the 'Evoke' prototype. Section 4 summarises the trials and their findings for the validation of the 'Evoke' prototype. Finally, Section 5 presents the conclusion and future work.

2. LITERATURE REVIEW

In recent years there has been rich research carried out in the field of AR assisted teaching at schools and colleges. This section covers recent literature relevant to the current study.

Many researchers have suggested applying AR-based learning into classrooms for subjects including mathematics, astronomy, chemistry, biology etc. through augmented books. However, AR has not seen that much success in the education sector due to insufficient funding from governments, and lack of AR needs awareness in this field (Shelton, 2002). According to Johnson, et.al. "AR has strong potential to provide both powerful contextual, on-site learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world." (Johnson et al., 2010).

An interesting study used AR in an astronomy class for learning the relationship between the Sun and Earth. The AR system used 3D rendered Sun and Earth shapes. Using a Head-Mounted Display (HMD), the students were able to control the viewing angles of the system elements (Shelton & Hedley, 2004). Another research team tried to teach students about chemistry by using AR through a gripper, a cube, and a booklet. The booklet displayed printed pictures and names of different components; the user reads this information by clicking the gripper button. The user moves the gripper next to a cube, which holds a molecule. Then by rotating the cube, the user determines how and where to connect the element to the molecule (Fjeld & Voegtli, 2002).

Similarly, AR has been used to teach biology. The teachers can use 3D models for displaying human organs to the students in real classrooms. The students can also use HMD to study the biological structures of the human body (Lee, 2012). In an interesting study, Chang et al. developed an AR application called Construct-3D for teaching mathematics and geometry with 3D models. This system allowed students and teachers to share a collaborative virtual space, and they were able to construct geometric shapes through HMD (Chang, Morreale, & Medicherla, 2010).

The AR systems can be especially useful in electrical engineering courses. It allows interactive study and laboratory practices with fellow students and even without the assistance of a teacher (Martín-Gutiérrez et al., 2015). The SMART (System of augmented reality for teaching) an AR-supported educational system has been used to teach students about animal types, and different transportation means through 3D models of animals and transportation. As children love playing games, they got more motivation for learning through AR support, which eventually had a positive impact on their learning experience (Freitas & Campos, 2008).

Chen et al. developed an AR technology called Fishing and Food Chain. The purpose of the game was to teach students different things about fishing, and they enjoyed it (Chen, Ho, & Lin, 2015). Other than these, the AR technologies can be used to teach students about cultural heritage, history of countries, industrial maintenance etc. A comprehensive literature review summarised that approximately 51% studies done so far in the AR field have focused on the K-12 (kindergarten to 12th grade) students, 29% on the university students and 9% on the adult learners. The findings suggest that as usual, young students like to play digital games. Therefore they are the most suitable group for such research (Akçayır & Akçayır, 2017).

The literature shows emerging research interest in AR and its applications in Education. However, the questions like AR usability in education, their efficiency, compatibility with traditional teaching methods etc. still need answering (Shelton & Hedley, 2004). Additionally, previous studies are focused on introducing AR in different educational subjects for adults, not targeted at children. This project aims to bridge this gap by developing a real-time AR interactive learning prototype for children. The system testing involved: delivering lesson through Moe, knowledge retention and usability evaluation of the Evoke prototype from both the children and their teachers.

3. THE EVOKE PROTOTYPE

The project used a wide range of hardware components across two locations (audience and operator rooms) to give the illusion that an animated character is interacting with the audience in real-time. The audience is located in the audience room. The room has the Imagination Station, which enables the audience to view and interact with the Avatar (Moe). The operator/teacher is based in the operator room. The operator room has the Toybox, which enables the teacher to interact with the audience and get video/audio feedback from the audience.

3.1 The Audience Room

The main display cabinet (Imagination Station) is located in the audience room as shown in figure 1. The audience will be young children, who it is hoped will engage with the animated character in a more enthusiastic manner than just being talked to by an adult. The cabinet is a custom-built wooden enclosure with hardware consisting of a Transparent Television Display, CCTV/Video Camera, Display Caster (Input), HDMI Streamer (transmitter), HDMI Converter (if using CCTV camera), Sound Bar and Multi-plug extension. The display caster streams from the operation room PC to the transparent television (Imagination Station), while the television screen displays the output.

Figure 1. *Audience room with children looking at Moe*

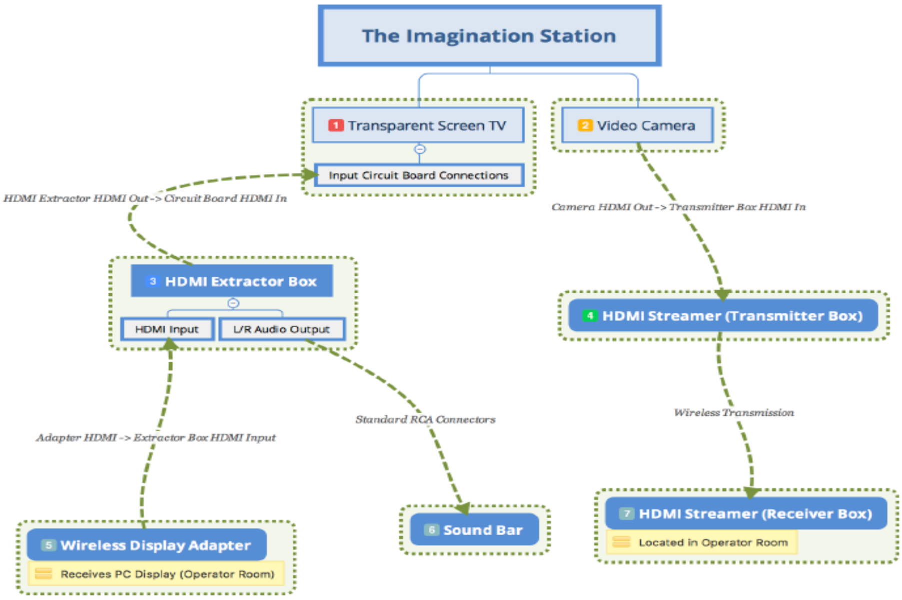

Figure 2. *Imagination station connection diagram*

The camera's video and audio feed are transmitted back to the operator wirelessly through the HD streamer (HDMI Converter (if using CCTV camera)) allowing them to see and hear the audience. The Imagination Station has a separate sound bar that outputs the television sound. Figure 2 shows the connectivity schematic for the various hardware components of the Imagination Station.

3.2 The Operator Room

The operating room can be smaller than the audience room, with enough space to contain all the operator equipment (Toybox) as shown in figure 3. The operator should typically be a teacher who can perform the character of Moe. The hardware composition of the Toybox includes the main PC, Kinect V2 Camera, Kinect for Windows adaptor, HDMI streamer (receiver), two monitors, wired headphones with microphone, two audio extension cables, multi-plug extension, game controller, and a USB mouse. Figure 4 shows the connectivity schematic for the various hardware components of the Toybox. The Kinect 2 camera maps the operator's movements to the on-screen avatar during the performance, and it is connected to the PC via the Kinect for Windows Adapter.

Figure 3. *ToyBox in operator room controlled by the teacher*

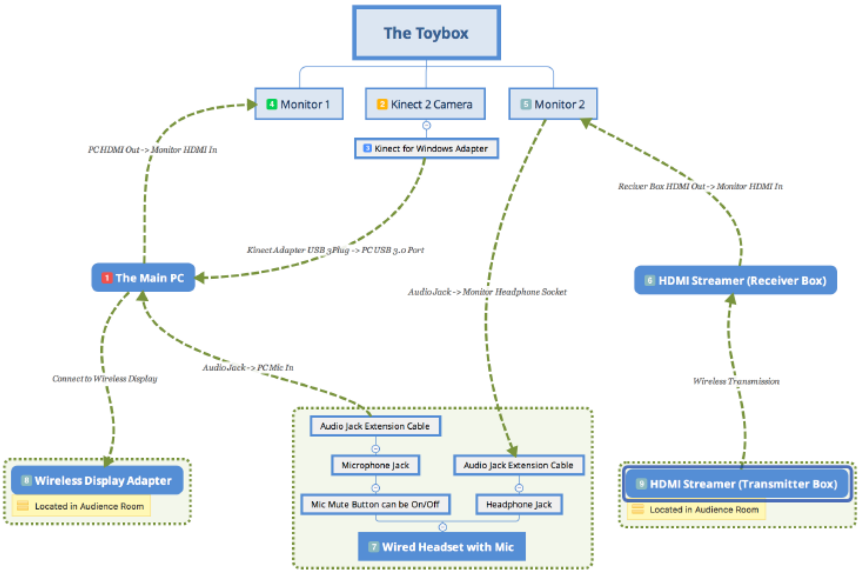

Figure 4. *Toybox connection diagram*

3.3 Spatial and Environmental Considerations

The ToyBox is a large box, and the Kinect 2 camera view of the operator requires that a degree of open space as specified by Microsoft available to allow the operator to perform (Misrosoft, 2018). The Microsoft Wireless Display connection has a limited range. Hence, the Imagination Station and the Toybox should be no more than 23 feet apart with a single wall between them for optimum performance (Microsoft, 2018). It is also advisable to avoid other 5.2GHz functioning wireless device in the area to prevent interference.

3.4 The Moe Character Design (The Program)

The Evoke character runs on Microsoft Windows. The character was developed using Unity (a multi-platform 3D game engine). Once launched, the program shows a standard Unity control panel, which allows the user to change the display resolution of the program, as well as remap the game controller buttons to the various functions allowed in the program (Smile, Frown, Reset Face, Raise Curtain, Lower Curtain, and Start Performance). The main interactive part of the program is the setup screen as shown in figure 5.

There are three selections to make before any performance: -1) select the microphone – choose the microphone to use for voice input, 2) select a character – place a tick next to the character to use, and 3) select voice alteration – choose the type of voice modification required. Once the operator has made these selections, the Start button is enabled. The operator can move into a position where the Kinect camera can ‘see’ them (the avatar will move from the ‘T’ pose to mimicking the operator’s posture). Once the operator is happy and ready, they can press the Start button on the game controller, which will set up the program with the ‘curtains’ lowered ready for the audience.
The children can be brought in to the audience room ready for the performance to begin. When the operator is ready, they can use the game controller to raise the curtain, revealing the avatar on a white background, and can talk to / interact with the audience by speaking into the microphone. At this stage, subtle movements are better than moves that are more outrageous. The display on monitor 2 allows the operator to see and hear the audience response.

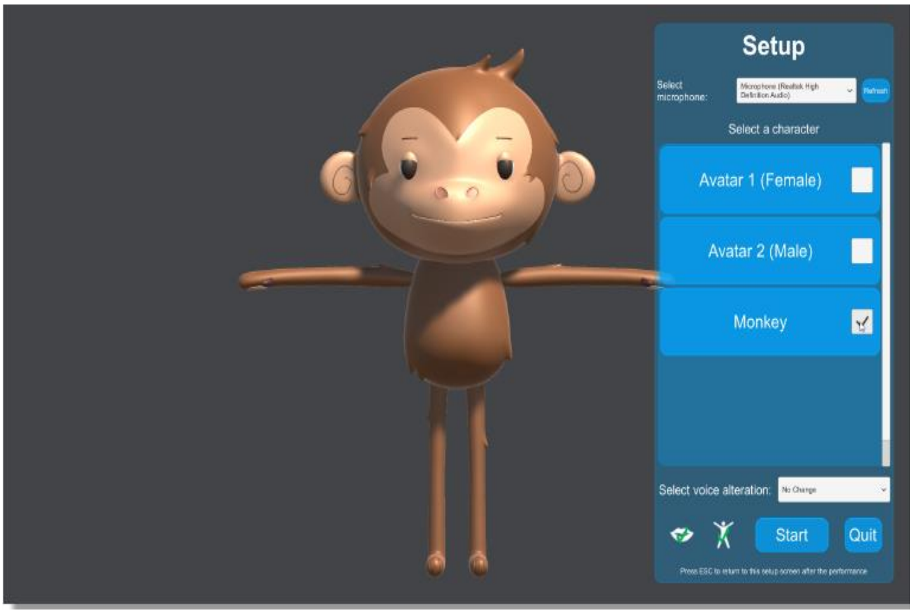

Figure 5. *Program Set-up Functionality*

4. EVOKE TRIALS WITH SCHOOL CHILDREN

By acknowledging the lack of application of AR technologies at schools, this study is initiated to bring AR into mainstream learning. Evoke Education and the Centre of Excellence in Mobile, and Emerging Technologies (CEMET) developed a real-time interactive learning application for children. Working collaboratively, CEMET has supported the development of the ‘Evoke’ prototype. The product has been tested with children and teachers in Wales to ensure the developers address all aspect of the user experience. This section summarises the testing and trials done with children and their teachers to test the efficacy of the Evoke prototype.

4.1 Interface and Function Evaluation

The ‘Evoke’ prototype is developed using an agile methodology which uses “iterative work sequences that are commonly known as sprints”. Therefore two children were informally involved at different points to test the interface and functionality of the Evoke prototype. Based on their responses the Evoke prototype was modified, and functions were revised many times before the final testing.

4.2 System Usability and Stability Evaluation

The pilot studies after every sprint helped to finalise the Evoke prototype based on the actual requirements of the children. In total 13 school children participated in the final testing and trials for the Evoke prototype in a classroom setting. The children ages ranged from 7 to 10 years. The children and teachers were asked to complete short questionnaires after each testing activity. The children were helped to complete their questionnaires by a member of the test team. The final testing phase included the following steps:

- Setting up a classroom with children
- Setting up an operator room with a teacher controlling the movements of Moe
- Delivering a lesson through Moe
- Asking a series of questions to children through Moe to test their knowledge retention
- Asking the children and teacher to fill out the questionnaires to investigate the usability of the Evoke prototype.

The questions for the questionnaires were formulated based on the ease of use, attractiveness, learnability, and efficiency of Evoke prototype. For the knowledge retention part, the teacher (through Moe) asked questions of the children about different aspects of the story narrated to them, while test team members noted their answers. For the usability questions, the test team members distributed paper-based questionnaires among the children and teacher. They spoke to the children and helped them to complete these questionnaires.

4.3 Questions and Answers

The children and teachers were given the opportunity to give answers to some questions at the end of the testing and trials. Short and simple questionnaires were used for this purpose. The summarised information arising from the questions asked to children and teachers is presented in table 1 and table 2 respectively. The children liked Moe as a teacher and were interested to know more about the character and listen to what Moe had to say to them. They were very excited to answer the questions that were asked by Moe and liked the shape, facial features and the body movements of Moe. They were also eager to carry out the task set out by Moe. These tasks increased the children's enthusiasm and interactivity with Moe. According (Ibrahim and Al-Shara, 2007) the core focus of educators is to increase students' retention and achievement. Previous research around this area indicates that increasing interactions during teaching sessions between students and their teachers can increase their achievement and knowledge retention (Fredricks et al., 2004). Hence, an increase in engagement between the students, and their teachers can increase their knowledge retention.

Table 1. *Summary of questionnaires data from the children*

Q. No.	Questions	Feedback on Experiences	Suggestions
Q 1	What do you think about the Moe?	The children liked the character and were interested to know more about the character.	
Q2	Do you understand what Moe is saying?	The children understood what Moe was saying.	The Welsh language could be clearer.
Q3	What did you learn from Moe?	The children came to know Moe's favourite food, Television show and that Moe can swim.	Moe to make some more body movements.
Q4	What do you like about Moe?	The children liked Moe's action, facial expressions. They were happy with the way it is.	They want to see more actions from Moe.
Q5	What do you want to ask Moe?	The children asked Moe few questions, and Moe replied happily.	
Q6	Are you scared of Moe?	The children were not scared of Moe. Moe was nice and a very good talker.	
Q7	Would you be interested if Moe teaches you at School?	Yes, from every one	

Table 2. *Summary of questionnaires data from the teacher*

Q. No.	Questions	Feedback on Experiences	Suggestions
Q 1	How did you find connecting to the Evoke Toybox?	It was easy to connect. Teachers in the school know IT equipment well, it would not be a problem for them to connect such equipment.	Training is required to familiarise with this.
Q2	Can you start the program and raise the curtain?	Yes, the teacher was happy to raise the curtain and start the program. She was happy to operate the hand-held controller.	Teachers need a lot of practice to get used to the multitasking while using this equipment.
Q3	Can you see the children in the Audience room?	Yes, the teacher can see the children.	
Q4	How easy to speak using the wired Microphone?	Getting used to the process is required.	More and more practice will help.
Q5	Are you able see and hear the audience?	Yes, can hear the children. There is no time lag.	
Q6	How did you find narrating the story by making different body movements?	It's fine in narrating the story.	Needs to prepare for the lesson beforehand.
Q7	How was the knowledge retention of the children?	It's really good; children remembered everything.	Teachers could use this for different school projects.

Table 1 summarises the children responses to the usability questionnaires about Moe as their teacher. Table 2 summarises the teacher's usability questionnaires. According to both tables, the children and teachers were happy with the testing activities and performance of the 'Evoke' prototype. Furthermore, the interaction with Moe was easy and fun filled. The teachers also agreed that the children were able to grab useful information from Moe during their lessons. As most of the modern day teachers are IT literate, therefore having them integrate this current prototype to their teaching would not pose many challenges. However, more teacher training will be required. The results of this testing are promising, as it highlights the need for this technology in education. However, additional test and more details test for generalising these result are required.

5. CONCLUSION AND FUTURE WORK

This paper focused on the development and testing of an AR-based Evoke prototype for enhancing child education. The system development followed agile methodology by involving children during development. The results of initial testing and trials revealed that children like Moe as their teacher and showed considerable interest in learning from Moe. Interestingly the testing results further highlight that the children were able to grab and retain useful information from Moe.

For results generalisation, the research team is conducting further trials with schoolchildren and their teachers to see the potential of Moe being their classroom teacher. Another interesting future research direction would be to have a controlled group and involve different age groups of children to test Evoke usability The psychological research on the benefit of using AR within education and its effect on knowledge retention would be a great contribution to the body of knowledge. Evoke Education and CEMET are also keen on researching the possible usage of the 'Evoke' prototype for professionals to interview vulnerable children as children can speak more openly to Avatar as compared to humans. The future research will aim at answering the following research hypotheses:

H1: The use of AR has a positive impact in educating children than in non-traditional manners.

H2: The children feel more connected to an AR character than a real teacher or professional child counsellor.

H3: Through the use of AR character, the children grab and absorb more information than traditional teaching methods.

H4: The children want to retain AR character as their teacher.

Testing of these hypotheses through further trials will present a clear picture of the true potentials of using Moe (AR systems) in educational settings and their impact on children learning. Additionally, the range of movement of Moe are limited, and the system has a degree of set-up overhead as well. Further work is required to overcome these limitations.

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