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Measuring the Effectiveness of Augmented Reality as a Pedagogical Strategy in Enhancing Student Learning and Motivation

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Abstract
The aim of this study was to explore the use of augmented reality as a teaching and learning tool in primary schools. This study examines the differences in students' performance and motivation to learn between two groups of students, which were taught the same topic, but different styles of teaching were used. A quasi-experimental research design was used for this study. A free Google Apps known as 'Aurasma' were used to create the AR 'aura' of the lesson, which was used in the experiment class. A pre and post-test for both performance test and motivation to learn questionnaire were administered to both classes. The study found that there were significant differences in performance and motivation to learn between the experiment class and control class. This study would benefit many parties as it proves that there is a need for changes in our current way of teaching in schools.
Keywords: Augmented Reality, Teaching and Learning, Performance and Motivation

Introduction
Since the advent of the microprocessor, computers have become ubiquitous in the workplace and society (McKay, 2005). As a result, there have been observable changes in computer and information communication and technology (ICT) tool usage in the workplace that involve the relationship between work, private and public life (Bradley, 2006). According to Shamoail (2005) in many areas of our daily lives, ICT has become increasingly prevalent, for example logging trip mileage in our cars, cooking meals in microwave ovens, managing the temperature in refrigerators, and selecting the right brew in coffee-making machines. Previously, it was thought that computers were used exclusively for manipulating data; however, for the younger generation, particularly those who were born in the 1990s, ICT tools have become part of their social life.

In one of his most debatable articles, Prensky (2001a) strongly suggests that the generations of today are changing. Prensky states that these new generations "think and process information fundamentally differently from their predecessors" (p. 1). He refers to them as *digital natives*. Others describe them as *millennials* (International Education Advisory Board, 2008), the *net generation* (Tapscott, 1998) or *generation-Y* (Holley, 2008). These new generations are assumed to be techno-savvy, where they possess knowledge and skills of new media that older generations have difficulty coping with. For these *digital natives*, giving them a new ICT gadget is no problem because they will be able to work it in a matter of minutes. This tendency is due to their ability to *assimilate* technology, while for the older generations they need to *accommodate* new technology (Tapscott, 1998). The newer generations were born with the new technology. To them, “digital technology is no more intimidating than a VCR or a toaster” (Tapscott, 1998, p. 1).

Consequently, teachers needed a new pedagogical methods for the integration of ICT tools into classroom activities (Mat-jizat & McKay, 2009). It is said that the computer-based skills that the *digital natives* possess today influenced the skills and interests in education in a very significant way (Bennett et al., 2008). According to Prensky’s observation, many of today’s tradition-bound educational systems seem to try to ignore their eyes, ears and intuition, and pretend that this issue does not exist (Prensky, 2001b). There is a substantial disparity between the technological skill and interests that these *digital immigrant* (born prior to 1980) teachers possessed, compared to the unlimited methods of technology-based or blended teaching strategies currently available (Levin & Arafeh, 2002; Prensky, 2005).

Aside from that, 21st-century learner (or *millenials*) learned differently from *digital immigrants.* They were described as like to be in control, like choices, group-oriented/social, practiced user of technology, think differently, values time off and more likely to take risks (International Education Advisory Board, 2008). *Millennials* also preferred visual communications, they engaged electronically, favoured adaptivity and connectivity, and one of the most important tools for *millennials* is not the computer, but the smart phones that so many of our schools currently banned (Prensky, 2006).

In a dialog session on the 2016 aspirations of the Malaysian Ministry of Higher Education, given by the Malaysian Director General of Higher Education, Professor Dato’ Asma Ismail recently, she highlighted the different learning styles between *digital immigrants* and *millennials.* She also emphasised on the importance of educators to be up-to-date with these changes and be more adaptive. The different learning styles were described as below (Table 1):

Table 1
Different learning styles by generation

	Baby Boomers	Generation X	Generation Y
Preferred learning culture	Collegial	Relevant	Supervised and structured
Learning materials	Major headings with information	Facts up-front	Visual stimulation
Learning likes	• Recognition of experience • Group activities • Practicing new skills	• Asking questions • Challenging material • Interaction/ socializing	• Edutainment • Multi-sensory • Collaboration
Learning dislikes	• Criticism • Role playing	Non-value added activity	• Confronting people issues • Asking for help
Instruction	Do not like authority	Demand competence	Will help instructor
Feedback	Once a year with documentation	Interrupts and asks how they are doing	Wants feedback at the push of a button

In relevance to that, this study attempts to explore the use of AR as a teaching and learning tool in primary schools. Amidst the rapidly changing technological environment, AR was advocated as one of the new technologies that could initiate active learning and at the same time promote creative and innovative thinking. AR can provide a unique and interactive experiences to students and are able to facilitate the understanding of abstract problems. However, in Malaysia, studies on AR are limited and studies on the use of AR as teaching and learning tools are even fewer. The technology is still new, and a gap of its possibilities needs to be researched and explored.

Research Aim and Objectives

This study examines the educational use and impact of AR experiences with primary school students. A quasi-experimental research design was implemented. Two groups of students were chosen and both were taught on the same pre-identified topic, albeit using two different methods; 1) the conventional way, and 2) using AR. A free Google Apps known as 'Aurasma' was used to create the AR 'aura' which were used in the experiment group, containing the topic lessons. Smart phones were used to view the AR auras.

To ensure that the research aims were met, the research objectives for this study were to:

i. Identify the difference in students' performance score for Design and Technology subject before and after the used of AR (experiment group) compared to conventional method (control group);
ii. Identify the students' level of motivation to learn Design and Technology subject before and after the used of AR (experiment group) compared to conventional method (control group); and

Generational Learning Styles

Learning styles were not only differed based on the different cognitive styles and preferences. The generational differences also play an important role in educating the young minds. Those who were born after 1980's were known as the *millennials*. These generation were accustomed to multimedia and doing everything at the same time. Their multitasking behaviour were said to shortened their attention span and could cause them lack critical thinking skills (Nicholas, 2008). The *millennials* were described as confident, honest, demanding, vocal and have high expectations when it comes to learning (Schofield & Honore, 2009).

In their study, Schofield and Honore (2009) found that *millennials* usually portrays these preferences in learning:

- Doing is more important than knowing - results and actions are now more valued than accumulation and memorisation of facts (knowledge);
- A need for immediacy – they have little tolerance for delays. Issues of time and difficulty in obtaining information are usually of more concern than accuracy;
- Trial and error approach to problem solving – as a result of not wanting to accumulate knowledge, they are more interested in problem based learning;
- Low boredom threshold – they have short attention span, lacks concentration;
- Multitasking and parallel processing – they are comfortable when they are engaged simultaneously in multiple activities;

- Visual, non-linear and virtual learning – visual modes of learning are preferred, and are more oriented towards, non-linear and non-sequential learning;
- Collaborative learning – they value interaction, networking, active participation and staying connected; and
- Constructivist approach – value both social and personal learning within a community context. They seek knowledge as an active creation process and are used to contributing and customising their work/knowledge to the community.

Understanding and Teaching the Millennials

To be able to understand and teach the *millennials*, one must accept and appreciate the differences that these group of learners have. They were born in a different world, filled with technology, and they were only reacting to what their environment are providing them. If teachers want to appeal to this generation, they will need to dramatically change the way they are teaching now. *Millennials* prefer kinaesthetic and visual learning activities over traditional teacher-centered and text-based tasks (Price et al., 1981).

To increase motivation to learn, we need to get students moving and include visuals in our teaching and learning activities (Reilly, 2012). Powerpoint presentations, Youtube videos and drawings can increase the nature of visuals in teaching and learning activities. They also prefer entertainment and games. So, try to imitate the entertainment and games environment in the student teaching and learning activities.

Aside from that, *millennials* also seeks purpose and passion and are feedback dependant (Reilly, 2012). In order for them to commit to something, they need to understand how they can fit and contribute into the situation/problem. They have a high sense of pride towards their own accomplishment and they need their community acknowledgement. The

acknowledgement or feedback that they received will further increase their commitment and passion to do better.

Therefore, a new and exciting tool for teaching and learning that could fulfill all the *millennials* teaching requirements is very much needed. This study has chosen AR as the new platform that could increase *millennials* motivation to learn and at the same time increase their academic performance.

Augmented Reality

Augmented reality (AR) is a technology that allows an image, video or animation to overlay a chosen image known as trigger image, in a real-world environment in real time (Carmigniani et al., 2011; Chang, Morreale, & Medicherla, 2010). Dunleavy and Dede (2014) proposed that there are two forms of AR that are currently being used in education: 1) location-aware; and 2) vision-based. Location-aware AR relies on GPS-enabled smartphones and the AR media will be activated based on the GPS-location, while vision-based AR requires the learner to point their smartphones to a triggering object (Dunleavy & Dede, 2014).

Studies had shown that this technology can be implemented in areas such as maintenance and repair (Henderson & Feiner, 2011), medicine (Yeo et al., 2011), automotive (Ng-Thow-Hing et al., 2013), and architecture, engineering and construction (Chi, Kang, & Wang, 2013). For example, an AR that uses a combination of image, audio and animation can provide an interesting interactive experience to help student understand the process of photosynthesis.

Aside from that, previous studies had shown that AR had been a successful tool in supporting teaching and learning from pre-schools to institutes of higher education (Dunleavy

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& Dede, 2014; Dunleavy et al., 2009; Kaufmann & Schmalstieg, 2003; Wu et al., 2013). It was anticipated that AR could strengthen students' motivation for learning, enhance their educational realism-based practices with virtual and augmented reality, increase knowledge retention and also encourage self-directed learning among students (Billinghurst & Duenser, 2012; Chang et al., 2010; Mat-jizat et al., 2016).

However, studies of the use of AR as teaching and learning tools in Malaysia are quite limited. The technology is still new, and many researchers are excited to explore its possibilities.

In this study, a free to download mobile application for iOS and Android that explores the use of AR called Aurasma (Figure 1) was chosen to be used as the tool to view the AR which has been created. The application is basically depended on the image, audio, video or animation that teachers can create for their teaching and learning activity. The image, audio, video and animation must not be more than three minutes and less than 100MB in size.

Figure 1. Aurasma logo

Some of the benefits that Aurasma can bring to the classroom are by bringing a lesson to life and making them more engaging. By using videos or pictures, teachers can explain lessons like Photosynthesis and the Solar System easily, more interesting and alive. Students can also learn at their own pace. Whenever and wherever they need to know about the lesson, they only need a mobile device and a triggering image that would trigger the AR Aura.

Aurasma is also a Web 2.0 based application. Each individual can sign up into the application and create their own Channel. The application allows user to Subscribe to Channels, which will allow the user to view other peoples' Aura and also leave a comment.

Design and Technology Subject for Primary Schools

Design and technology subject was introduced in Malaysian Primary Schools based on the Malaysian Primary Schools' Curriculum Standard. The main reason for the inclusion of the subject was to introduce basic skills in technical, agricultural technology and home science to primary school students, to prepare them for their future (Figure 2).

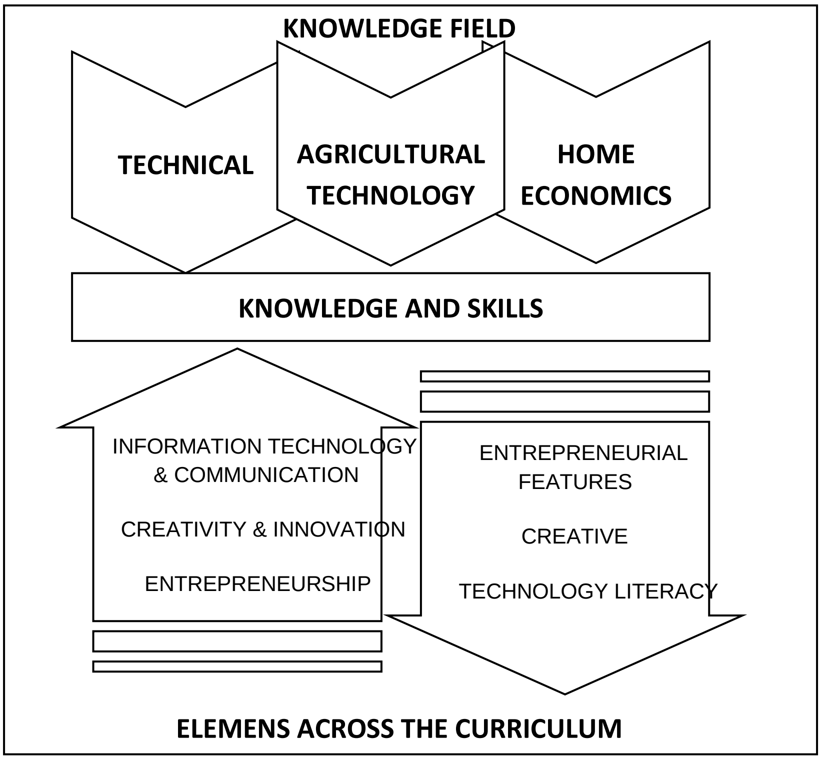

Figure 2. Design and technology curriculum design Topics discussed in this subject include

i. Workshop organisation and safety
ii. Basic technology
iii. Design
iv. Project production
v. Agricultural technology
vi. Home science.

In Basic Technology, one of the activities proposed for this topic was assembling and disassembling of a functional model car kit. Each student was given a set of disassembled functional model car kit. Following the teachers' instruction and demonstration, students were expected to assemble the functional model car kit.

In usual cases, teachers will need to do the demonstration numerous times in order for the students to really get it. This will take a lot of class time, and plus, not all students needed the extra demonstration time. Some of them just get it the first time, and some prefer to selflearn.

AR provides the alternative needed for this dilemma. For the purpose of this study, three short video based on the topic of assembling and disassembling of a functional model car kit were used. The video used in this study were the videos uploaded by Youtubers: 1) cg kh; 2) Ahzan Salvinawati Ahmad; and 3) Shamsul Anuar. The first video (Figure 3) explained all the tools needed in order to assemble/disassemble the model. This video also describes the function of each tool. The duration of this video was 42 seconds.

Figure 3. Snapshots of video 1 (source: Youtube Channel cg kh)

The second video (Figure 4) introduced the students to all the components for the functional model car kit. Again, this video also explains the function of each component. The duration of this video was 25 seconds.

Figure 4. Snapshots of video 2 (source: Youtube Channel Ahzan Salvinawati Ahmad)

The third video (Figure 5) showed the students the step-by-step process of assembling and disassembling the functional model car kit. The duration of this video was 3 minutes 34 seconds.

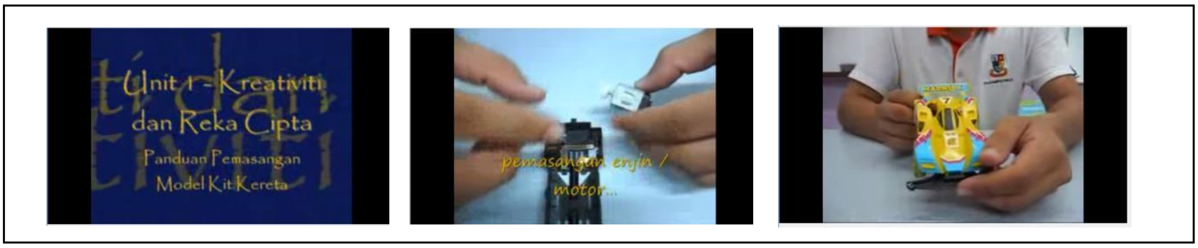

Figure 5. Snapshots of video 3 (source: Youtube Channel Shamsul Anuar)

A triggering image (Figure 6) had been chosen and linked to each video. In this study, three triggering image had been colour-printed and laminated, and given to all the students in the experiment class. In class, four tablets were used to allow the students to view the auras. The students were divided into four groups, and each member of the group takes turn to view the auras. Only one aura were introduced each week. The teacher also showed the students how to create an account with Aurasma. This allows the students to view the auras using the triggering images at home, using their parents' mobile devices.

Figure 6. Triggering images for the auras.

Methodology

For this study, the quasi experimental research design was chosen due to the limited leverage and control over the selection of participants. The researchers do not have the ability to randomly assign the participants or ensure that the sample selected is as homogeneous as desirable, as to avoid disrupting the schools' operation. Nonrandomized Control Group PretestPosttest Design was selected as to allow the researchers to measure participants' initial performance score and motivation before any treatment were given, and later compare both score after treatment in order to calculate changes (Campbell & Stanley, 1963; Cook & Campbell, 1979).

T1 — X1 — T2

C1 → X2 → C2

Legend:
T1 : Pre-test for experiment group (using AR)
T2 : Post-test for experiment group (using AR)
C1 : Pre-test for control group (using conventional method)

C2 : Post-test for control group (using conventional method) X1 : Using AR
X2 : Using conventional method

Figure 7. Nonrandomized control group pretest-posttest design

Figure 7 above showed the research design for this study. Two standard four classes from the same school were selected to be the participant for this study. One topic from the Design and Technology subject was chosen and both the experiment group (T1) and control group (C1) were given the same test questions. The questions were developed in order to test the participants' preliminary knowledge about the topic. This will be the benchmark for both groups (T and C) performance score.

Group T were then being taught on the topic of *Basic Technology: Assembling and Disassembling of a Functional Model Kit* using AR as the learning aid. Meanwhile, at the same time Group C were also being taught on the same topic, however for this group, the teacher were asked to use her conventional teaching methods. At the end of the topic, both groups were tested again (T2 and C2) using the same test questions given during pre-test. The difference this time was that the questions were re-arranged in a different order.

Research Instrument
Two types of instruments were used in this study. The first one was a questionnaire which was used to measure the participants' motivation to learn, and the second instrument was a student performance test questions which was used to assess the participants' performance score.

Student Performance Test Question
The student performance test question was designed based on the Design and Technology syllabus provided by the Malaysian Ministry of Education. The topic chosen for this study was 'Basic Technology: Assembling and Disassembling of a Functional Model Kit'. The test question consists of a combination of multiple choices, sequencing and matching pictures questions. The test question was given to both the experiment group and control group twice. The first time, it was given prior to the topic been taught to any of the classes. This was to identify the initial knowledge of the chosen topic that each of the participants have. The second time, the same question was re-arranged in order to reduce *testing bias*. In a quasi-experimental study, the effect of giving the pretest may affect the outcomes of the second test (Campbell & Stanley, 1963). Rearranging and changing the order of the questions may help in reducing bias.

Motivation to Learn Questionnaire
The motivation to learn instrument was adapted from Ersoy and Oksuz (2015), who designed the questionnaire to determine the motivation of primary school students towards learning mathematics. Based on their analysis, the instrument was highly reliable and has adequate power to predict the items' total score (Ersoy & Oksuz, 2015). The instrument is suitable for evaluating motivation of primary school students in general, but it does not differentiated between intrinsic motivation and extrinsic motivation.
The instrument was originally consists of 33 questions, with 3-point scale. However, for this study, question no 19, "I am good at in skills of making prediction in mathematics subject" was removed as this question was referring to a specific mathematical skill, which was not necessary in a Design and Technology subject.

Data Analysis and Findings
For this study, two hypothesis had been identified to be tested. The findings for each hypothesis were described separately.

Hypothesis 1
$H_0$1: There is no significant difference in students' performance score for Design and Technology subject before and after the used of AR (experimental group) compared to conventional method (control group).

In order to ensure that the students in both classes were equally divided academically, independent samples T-test was conducted upon their pre-experiment performance score. The student performance test instrument was administrated to students in both classes prior to the lesson being delivered. The findings were described in Table 2 and Table 3 below.

Table 2
Mean, standard deviation and standard error mean for pre-experiment performance score

Performance	Mean	Std. Deviation	Std. Error Mean
Experiment	1.333	0.482	0.098
Control	1.400	0.500	0.100

Table 3
Independent samples t-test for pre-experiment performance score

Performance	Levene's Test		t	df	Sig. (2tailed)	Mean Difference	Std. Error Difference	95% C.I.	
	F	Sig.						Lower	Upper
Equal variances assumed	0.874	0.355	-0.475	47	0.637*	-0.067	0.140	-0.349	0.216

*Significant level < 0.05

Some of the students did have prior knowledge on some part of the lesson such as the tools used to assemble the car model kit. However, there was no significant difference in performance score for both the experiment class (M=1.333, SD=0.482) and control class (M=1.400, SD=0.500) in this pre-experiment stage, where t(47) = -0.475, p = 0.637.

To test $H_0$1, paired samples T-test was conducted on students' performance score in both classes by comparing mean score for post-experiment to mean score pre-experiment (Table 4). Both classes showed significant difference (Sig. = 0.000). There was significant difference in performance score for both the experiment class (M=1.500, SD=0.659) and control class (M=0.920, SD=0.276).

However, the standard deviation in the experiment class was larger than the control class. The improvements in performance score were higher in the experiment class. $H_0$1 was rejected.

Table 4
Paired samples t-test for performance score

Performance	N	Mean	Std. Deviation	Std. Error Mean	T	Df	Sig. (2tailed)
Experiment (pre-post)	24	1.500	0.659	0.135	11.145	23	0.000*
Control (pre-post)	25	0.920	0.276	0.055	16.613	24	0.000*

*Significant level < 0.05

Hypothesis 2

$H_0$2: There is no significant difference in students' level of motivation to learn Design and Technology subject before and after the used of AR (experimental group) compared to conventional method (control group).

As before, an independent sample T-test was also conducted upon the students' motivation to learn scores. The instrument was administrated to students in both classes prior to the lesson being delivered. The findings were described in Table 5 and Table 6 below.

Table 5
Mean, standard deviation and standard error mean for pre-experiment motivation to learn

Motivation	Mean	Std. Deviation	Std. Error Mean
Experiment	2.410	0.196	0.040
Control	2.389	0.170	0.033

Table 6
Independent samples t-test for pre-experiment motivation to learn

Motivation	Levene's Test		t	df	Sig. (2tailed)	Mean Difference	Std. Error Difference	95% C.I.	
	F	Sig.						Lower	Upper
Equal variances assumed	0.502	0.482	0.409	47	0.684*	0.021	0.052	-0.083	0.127

*Significant level < 0.05

There was no significant difference in students' motivation to learn score for both the experiment class (M=2.410, SD=0.196) and control class (M=2.389, SD=0.170) in this preexperiment stage, where $t(47) = 0.409$, $p = 0.684$.

To test $H_0$2, paired samples T-test was conducted on students' motivation to learn score in both classes by comparing mean score for post-experiment to mean score pre-experiment (Table 7). Both classes showed significant difference (Sig. = 0.000). There was significant difference in performance score for both the experiment class (M=0.120, SD=0.087) and control class (M=0.047, SD=0.047). However, the standard deviation in the experiment class was slightly larger than the control class. The improvements in students' motivation to learn for the experiment class were slightly more than the control class. $H_0$2 was rejected.

Table 7
Paired samples t-test for motivation to learn

Motivation	N	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2tailed)
Experiment (pre-post)	24	0.120	0.087	0.018	6.763	23	0.000*
Control (pre-post)	25	0.047	0.047	0.009	4.922	24	0.000*

*Significant level < 0.05

Discussion

For this study, the students were given a performance test and a motivation to learn questionnaire before and after the experiment. The questions were the same, but were rearrange in order to reduce bias.

For the performance test, the first time the test was given, it was to identify the students' prior knowledge and to check whether there was any significant difference (in background knowledge) between the two classes (experiment class and control class). The independent samples t-test proved that there were no significant differences between the two classes.

For the motivation to learn questionnaire, the findings explained that there were also no difference in level of motivation to learn at the beginning of the experiment. This becomes the point of reference in evaluating the differences (if any) after the experiment (post-test).

In the next three weeks, the students were taught on the topics of assembling and disassembling of a functional model car kit. The control class was taught using the teachers' usual way of teaching this subject, while the experiment class includes the AR auras in their teaching and learning tools.

After three weeks, the performance test and the motivation to learn questionnaire was administered again to the students. The findings showed that both classes had significant differences in their performance score and motivation to learn when compared between the students' post-test and pre-test scores. This was expected as regardless of the teaching tools used, the students should show signs of improvement in understanding the topic and their level of motivation, as they began to understand the topic after three weeks of learning. However, by looking at the standard deviation between the two, the findings showed that the experiment class had improved their understanding and motivation slightly more than the control class.

The use of technology, which the students were very familiar with, might have contributed to the difference. The use of AR as a teaching and learning tool have ticked so many boxes in the *millenials* study preferences suggested by Schofield and Honore (2009). The AR aura allows the student to pick and choose the topic that they wanted to study more, at any given time or place. As long as they have a mobile device with Aurasma mobile application installed. If any of the students encounter any problems while assembling or disassembling their functional car model kit, the students could just re-play the auras as many times as they wanted.

The videos chosen for the auras also were short in time duration, where the longest video of the three did not exceed four minutes of playtime. This really benefited the *millenials* students as they were said to have short attention span (Scofield & Honore, 2009).

Reilly (2012) and Schofield and Honore (2009) also described the *millenials* as visual learners and they value interaction and active participation in learning. The aura requires the student to become active learners. The students hold the steering in their own learning boat. If they want to move forward, they have to watch the videos in the auras. On the teacher part, teachers will now really play the part of a facilitator who facilitates the learning activities, instead of being the sole source of knowledge.

Research Implications

The finding of study could benefit many parties and could become the source for changes to be made in the way we are teaching our students today. If a 40 years old adult looked back at the way they were being taught in primary schools 30++ years ago, they would be surprise to see that not much have been changed, despite the changes in technology, way of living and way of thinking in the community.

This study have showed that *millenials* prefer technology and to them technology is part and parcel of their life, their existence. In order to attract them to learn, teachers must be able to manipulate the many new technological devices and applications to be used in their class such as Kahoot!, Quizzit, and Aurasma.

Technological devices and applications could also help students to learn at their own pace. Most teachers are usually worried about finishing their syllabus. At the same time they also wanted to help and give more attention to students who are a bit slow in catching up with other students. Application such as Aurasma allows the student to go back and forth in their lesson and keep on re-playing them until the student really understands.

Conclusion

This study proposed the used of AR as tools for teaching and learning in schools. Teachers must stay updated on the new ways and tools in teaching and learning as the students that they are currently teaching have been described as having a totally different surrounding growing up, where technological devices have been introduce to them by parents as early as one years old. Therefore, new tools and ways that include technology must be promoted and used in schools today. Findings from this study supported this view as the study showed significant differences in performance score and motivation to learn in students who were introduced to AR auras as part of their learning tools.

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