Augmented Reality as a Classroom Teaching and Learning Tool: Teachers' and Students' Attitude

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Authors' contributions

This work was carried out in collaboration among all authors. Author TL designed the study, prepared the study framework, wrote the protocol, did the literature review, ensured the coordination and timeline and compiled the first draft of the manuscript. Author PJ performed the statistical analysis, managed the result analyses, discussion and conclusion of the study and prepared the first draft of the manuscript. Author ST managed the literature searches and data collection. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

The use of Information Communication and Technology in teaching learning has been emphasized a lot in the recent times as an effective instructional tool and it will only grow and develop further. Augmented Reality is one of the futuristic pedagogy that will offer great opportunities in the incorporation of information technology in teaching and learning. Augmented Reality refers to the introduction of virtual elements in the real world. This will supplement students' learning through the use of technology. This study assessed the students' and teachers' attitude towards the use of Augmented Reality as a learning tool after they experimented and experienced the use of augmented reality through mobile application. For the teachers, a three-hour professional development session on Augmented Reality was conducted. Teachers were taught how to use mobile application to create Augmented Reality. For the students, research team created the Augmented Reality using a mobile application and let students experience it in a biology lesson. After the sessions, their attitudes towards the use of Augmented Reality was assessed through statements of agreement on a 5-point Likert scale. SPSS has been used for statistical analysis. The results show that both the teachers and students have overwhelming support-positive attitude towards the use of Augmented Reality in the classroom teaching and learning.

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1. INTRODUCTION

Augmented Reality (AR) refers to the introduction of virtual elements in the real world [1]. This will supplement students' learning through the use of technology. The person is seeing an image composed of a visualization of the real world, and a series of virtual elements that, at that same moment, are super-imposed on the real world. It is done through the use of smart phone application and computer generated information. Until recently, AR was mostly available for only powerful technological workstations [2]. Now the introduction of AR applications to smart phones enabled new opportunities to experience AR by the everyday users. Carmigniani and Furht [3] defines Augmented Reality (AR) as a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computer-generated information to it. AR is one of the futuristic pedagogy that will offer great opportunities in the incorporation of information technology in teaching and learning. AR can be used to link practical and theoretical learning approaches along with real and virtual components merged together to create a distinctive learning experience [4].

According to Rizov and Rizova [5], AR is found to significantly improve students' interest, motivation, understanding and interiorizing the learning material. Learners develop higher levels of independent thinking, creativity, critical analysis and their cognitive overload are also reduced [6]. Mobile computing technologies for learning affords user mobility resulting from device portability, relatively strong computing power in small devices, and always-on connectivity [7]. These affordances lead to tremendous potential for innovative uses of mobile technologies in classroom teaching and learning.

1.1 Objective

The objective of this study is to experiment with the use of Augmented Reality mobile apps as a teaching tool and assess students' and teachers' attitude towards its usage.

1.2 Situational Analysis and Literature Review

Quality of education in Bhutan is perceived to be deteriorating. It is the general consensus among all the stakeholders of Bhutanese education system. Royal Education Council [8] has confirmed that many of Bhutanese students are performing below expectations of their grade level on both basic and advanced academic skills. It also stated that most of our teachers are trapped in the teacher-centered chalk-and-talk system of teaching even though the curriculum require them to use varieties of pedagogies. Education Sector Review Commission [9] found that the "Culture of passivity" in learning occurs at all the levels and strongly urge shifting from a culture of fear to a culture of engagement in classrooms. Teachers at present are challenged to keep the digital native students motivated and engaged in the classroom. The use of ICT in teaching learning has been emphasized a lot in the recent times as an effective instructional tool and it will only grow and develop further in the 21st century [10]. ICT has been incorporated as one of the parameters in rating school self-assessment (SSA) as well as in teachers' individual work plan (IWP).

The main goal of this research is to experiment the use of AR as an instructional tool with the help of smart phone application and find whether it helps in students' learning by investigating their attitude towards the use of AR in classroom. Our students for most of the time cannot visualize and find it difficult to relate the 2-Dimensional images and figures that they find every day in their daily lessons. This study will experiment with the use of AR: how it helps in advancing visualization of complex concepts; how 2-Dimensional figures can be activated into 3-Dimensional images that resembles the real world; how it simplifies abstract ideas into self-directed learning experiences; and how AR appeals to the generation-Z digital natives as a teaching tool. This study will also find opportunities to explore integrating AR teaching tool with Flipped Classroom strategy. Similar to the findings of flipped classroom in reducing the instructional hours, AR applications is also expected to provide freedom and space of time to explore complex subject matter [11].

AR has been conceptually thought to be an abstract and complex high-end technology and thus there is insignificant or no explorations on its use in classroom teaching learning in Bhutan. As expressed by Hsu and Ching [7], technological advances enabled the use of AR by anyone interested in doing so. It requires a little

explorations on how it works and how it can be incorporated into daily lesson. Use of information, communication and technology (ICT) in teaching learning is becoming an integral part in every discipline and at all the levels. Through ICT, learners develop higher levels of independent thinking, creativity, critical analysis, and it reduces their cognitive overload [6].

With the ongoing debate on the quality of education in Bhutan, Ministry of Education is exploring means and ways to counter the perceived deteriorating quality of education. Ministry of Education is investing a lot in initiating trainings and programmes to help teaching learning processes, improve quality of classroom instruction, motivate students to learn that leads to advancement of students' performance, and thus improve the quality of education. Teachers throughout the country are provided with professional development programmes on different pedagogies that are assumed to bring in positive influence in the teaching learning process. They are also encouraged to come up with strategies and pedagogies that would augment students learning ability. But teachers find it very challenging to innovate, improvise and incorporate strategies that would keep our 21st century learners' engaged and motivated. Understanding the generational learning characteristics of digital natives make us realize that they prefer varieties of technological tools to be incorporated in teaching learning processes. The challenge now is to explore different ICT instructional tools.

AR is one of the futuristic pedagogy that will offer great opportunities in the incorporation of information technology in teaching and learning. The use of Augmented Reality (AR) in formal education could prove a key component in future learning environments that are richly populated with a blend of hardware and software applications [11]. AR is supplementing one's immediate surrounding with electronic data in visual, text, audio, video, or haptic overlay [12]. It combines the real environment and a virtual environment in a new space that enables augmented perception of reality [13].

According to Munnerlay et al. [14], there are two main forms of AR: artefact-based and geo-located. This study experiment uses artefact-based form. It uses physical markers that are scanned by a camera and then carry out an action such as displaying an animation, video, or 3-D image. It can be done using handheld smart

phones that offers the educational affordances of portability, social interactivity, context sensitivity, connectivity, and individuality [15,16]. They further state that it offers an ease of access to knowledge, learning without boundaries, opportunity for collaboration between teachers, students and parents, and improvement in student engagement and responsibility. Using AR for educational purposes can appeal to students at a personal level, promoting both engagement and motivation [5]. It can help learners to gain a deeper understanding, experience embedded learning content in real world overlays, or explore content driven by their current situation or environmental context [2].

AR can augment one's view and transform it with the help of a computer or a mobile device, and thus enhance the user's perception of reality and of the surrounding environment. In addition, within an AR-enhanced context, information becomes interactive and easily manipulated in a digital manner [17]. Most of the mobile application that are used to create and experience AR usually do not require any coding.

2. METHODOLOGY

2.1 Site

Shari Higher Secondary School.

2.2 Participants

109 students participated in this study. Participants were class 12 bioscience and class 9 students based on purposive sampling. Researcher implementing the use of AR tool currently teaches biology in class 12 and class 9 and the AR trial has been developed for these classes by the implementing researcher. It requires the use of smart phones and most participating students own a smart phone. It is also because they are deemed more responsible in using phones in the classroom. 55 teachers from two schools (Shari higher secondary school and Dramitse middle secondary school) participated in this study.

2.3 Data Collection and Analysis Tool

- *Observation and recording*: The processes of the AR implementation was observed by co-researchers and few teacher colleagues who also, on their own interest, experienced the AR supplemented teaching learning session. A feedback

session with teacher participants and few student participants on their observation was collected and used as the base for qualitative data for the experimentation of AR as a teaching learning tool. It was to be supplemented upon by co-researcher's observation and implementer's reflection.

- *Attitude Questionnaire*: For the attitude part, students and teachers were provided with attitude questionnaire that consists of positive and negative statements reflecting attitude attributes towards the use of AR. It is accorded with 5-point Likert scale from 1-strongly disagree to 5-strongly agree: Mean scores, one-sample t-test, and one way ANOVA are used for the statistical analysis of the quantitative data. Cronbach's alpha test has been conducted for the questionnaire. Each theme has an alpha value of greater than 0.72 and an overall alpha value is 0.89. As per thumb rule stated by Gliem and Gliem [18], an alpha value of 0.70 and greater is considered to have acceptable internal consistency.

2.4 Development of Augmented Reality

The study uses marker based augmented reality using Metaverse application as it is easy to use and develop as compared to other category [19]. Refer appendix A for steps involved in developing AR experience

For the purpose of this study the experiences were created for the concept of meiosis for grade 12 and genetic engineering for grade 9. The detail content of these topics were delivered through text, 3D images, videos and web-links. The experiences developed also contained the assessment part. It was done through multiple choice questions (MCQ), true or false statements and, short questions and answers. Students got to learn the concepts through 3D images and interact with the graphics.

2.5 Intervention

Prior to the AR class session with students, school based in-service programme (SBIP) was conducted by the researchers to the teaching staff of Shari higher secondary school and Drametse middle secondary school on the usage of AR as a teaching tool. They were made to experience the AR through Metaverse App and at the end of the session, they participated in self-monitored attitude questionnaire.

First session of AR class was carried out with grade 12 students to study the concept of meiosis. Students were first asked to download metaverse app and then briefed on the usage of application by the researcher followed by familiarization session. Once students were ready with the metaverse app in their phone, students were asked to scan the printed QR code. On scanning the code students could view the experiences created to study concept on meiosis. The class was led by one of the researchers while co-researchers along with school action research committee members observed the class. The time taken for instruction was 100 minutes. Similarly second session of AR class was carried out with three sections of grade 9 students to study genetic engineering. The session took 50 minutes each.

Researchers administered attitude questionnaire for AR to collect quantitative data from the participants, right after each session. A feedback session through semi-structured interview and reflection with the observers and few student volunteers are collected as a source for qualitative data.

3. RESULTS AND DISCUSSION

3.1 Demographic Information

A total of 55 teachers-33 male and 22 female; and 109 students-56 male and 53 female participated in the self-monitored attitude questionnaire.

3.2 Students' Attitude towards Learning through AR Tools

All the positive statements (statements that support the use of AR as a teaching tool) were categorized under the themes: Preference; Support learning; Interest and motivation; and Participation and engagement. 'Preference' reflect students' fondness in using AR in their daily teaching learning experience. The theme 'Support learning' encompasses the statements which agrees that AR help students understand the lesson better. The theme "Interest and motivation' includes the statements that reveals students' enjoyment and learning motivation. Statements that support teamwork, participation and students' willingness to engage meaningfully are themed as "Participation and engagement. Table 1 shows the mean scores of each theme for the positive statements. AR tool as an Information and communication technology have

potential to innovate, enhance, supplement, and deepen skills, to motivate and engage students [20].

All the positive statement themes have mean score of greater than 4.4 on the 5-point Likert scale. Students believe that AR will aid in their learning and keep them meaningfully engaged in the classroom. Botella et al., [1] also states that AR has the advantage of making students feel curious and engaged.

Negative statements despises the use of AR as a teaching tool. Negative attitude include AR being a waste of time; dull and boring; impractical or useless; and difficult for students. The statement 'AR will be challenging for students' is a means to observe weather students foresee challenges in the use of AR App. The mean scores for the same are as shown in Table 2.

With the mean scores all greater than 4 for all the positive statements and less than 2 for all the negative statements, there is a clear indication that students have positive attitude towards the use of AR as a teaching tool. As the mean suggests, the theme "Challenging for Students' seems to have divided view. As per the students' comment, this divided view is because they are using the AR app for the first time and like any other mobile applications, it will require some time to get familiar. The support is evident from Table 3 that shows one sample t-test of mean positive and negative scores with the neutral value of 3 in the 5-point Likert scale.

The differences of both the positive and negative statement mean score with the neutral test value

are highly significant with $p<.001$. This statistics strongly confirms that students garners a great deal of positive attitude towards the use of AR as a teaching tool in their daily teaching learning experience.

3.3 Teachers' Attitude towards Use of AR as Teaching Learning Tool

A total of 28 statements-18 positive and 9 negative statements, were grouped under different themes for the statistical analysis. The positive statements were themed as follows:

* Preference: This theme consists of the statements that indicates participants' liking of the AR tool, their emphasis and recommendation on the use of AR
* AR supports learning: This theme includes statements that supports AR's role in improving students understanding and focus, and facilitating meaningful learning
* Interest and Motivation: This theme comprises the statements that backs enjoyment of the AR tool that leads to their increase in motivation to learn
* Participation and Engagement: It encompasses the statements that accounts in AR leading to positive interaction, team building, meaningful engagement, and enhancement of participation in the teaching learning process
* Broader learning domain: The last theme for the positive statement covers AR helping students in cognitive development-creativity and critical thinking

Table 1. Mean scores for the positive statements

	Minimum	Maximum	Mean	Std. Deviation
Mean-preference for AR	3.00	5.00	4.7294	.42781
Mean-AR supports classroom learning	2.67	5.00	4.5092	.46804
Mean-Interest and motivation	3.40	5.00	4.6936	.36774
Mean-participation and engagement	2.00	5.00	4.4312	.63635

Table 2. Mean scores for negative statements

	Minimum	maximum	Mean	Std. Deviation
Time wastage	1	4	1.4	0.63
Dull and boring	1	5	1.3	0.59
Impractical/useless	1	5	1.5	0.86
Difficult	1	5	1.6	0.87
Challenging for the students	1	5	2.6	1.36

All the mean scores are above the neutral score of 3 on the 5-point Likert scale. It points out that teachers also have positive attitude towards the use of AR as a teaching tool. They believe that AR will enrich students learning experience and feel that AR can retain students' interest and motivation in learning, and keep them meaningfully engaged in the classroom. As expressed by Bower et al., [6], teachers also accept that AR has the potential to enhance students' independent critical thinking and creativity. It has the ability to completely immerse the learners in their learning experience [3].

Comparatively, students' mean scores are higher than teachers' mean score in all the fields. As per the observers in the implementation of AR, students are more opportunistic in being able to use mobile apps in the daily teaching learning process and they got to experience the AR in real teaching learning situation. As for the teachers, they only got an hour's session on the use of AR tool and they might not be thoroughly convinced with what AR could offer in the field of teaching learning. The mean score for the negative statements also depicts similar comparative result as shown in Table 5. Teachers' conviction in negative statements are not as strong as that of students.

The constituents of the themes in Table 5 are as follows:

- Time waste: Statement that argues AR is just a waste of time without any substantial advantage in the learning process.
- Boredom: This includes statements that articulate AR tools are dull and boring.
- Distraction: Statements assuming that AR through the use of mobile application as an object of distraction for students learning process
- Challenging: Statements that depicts AR as a challenging tool to use by the students

There has been an assumption that teachers of Lower classes might see AR as an overwhelming tool for younger students. Table 6 shows the mean scores for challenging view as scored by teachers teaching Lower Secondary level, Middle Secondary Level, and Higher secondary level.

The mean scores of AR being challenging for students show divided view. Students' attitude also has a similar view. FitzGerald et al., [12] also maintains that there are challenges associated with its use in educational situation. They also expresses their fear that students' focus might be more on shiny devices rather than learning objectives. The case of distraction is also the worry that technology might remove learners from the immediate experience of the location rather than augmenting it.

Comparing the mean scores of different groups based on classes taught, we notice slight differences in them. But with F=.582 and $p>.05$, as shown in Table 7, there is no significant difference between mean scores of the 'Challenging' theme between the groups.

The mean score of 4.1 for the positive statements and a mean score of 2.2 for the negative statements, as shown in Table 8, has significant difference with the neutral value on the 5-point Likert scale. The differences of both the positive and negative statement mean score with the neutral test value are highly significant at $p<.001$.

Table 3. One sample t-test for positive and negative scores

| | Test Value = 3 | | | |
	t	df	Sig. (2-tailed)	Mean Difference
Mean-positive statements	42.54	108	.000	1.590
Mean-negative statements	-29.21	108	.000	-1.548

Table 4. Mean scores for the positive attitude themes

	Minimum	Maximum	Mean	Std. Deviation
Mean-preference for AR	2.00	5.00	3.85	.540
Mean-AR Supports learning	2.75	5.00	4.15	.568
Mean-Interest and motivation	2.80	5.00	4.40	.595
Mean-Participation and engagement	2.50	5.00	3.94	.655
Mean-Broader learning domain	3.00	5.00	3.98	.672

Table 5. Mean scores for the negative statements

	Minimum	Maximum	Mean	Std. Deviation
Time waste	1	4	1.91	.845
Boredom	1	5	2.24	.942
Distraction	1	5	2.56	.811
Challenging	1	5	2.94	.746

Table 6. Mean scores of the theme "challenging' for grade taught categories

Grade taught	Mean	N	Std. Deviation
pp-8	2.80	10	.919
9-10	3.00	16	1.155
11-12	3.21	29	1.082

Table 7. One way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.35	2	0.675	0.582	0.563

Table 8. One sample t-test for the mean scores of positive and negative statements

			Test Value = 3		
	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Mean of positive statements	4.1	.518	15.46	54	.000
Mean of negative statements	2.2	.530	-10.58	54	.000

It is an encouraging positive sign for the use of AR tool in classroom teaching and learning. A study by Rizov and Rizova [5] found that students show significantly improved results in increasing the interest, understanding and interiorizing the learning material when they use AR as a teaching tool. They also found that using AR is significantly improving the learning process of students as well as teachers' teaching process in a pedagogical and technical sense. A multiple review on AR by Akcayir and Akcayir [21], found that the most reported advantages of AR was the enhancement of learning achievement. They also reported usability issues and technical problems as the most recurring challenges.

The challenges at the present moment is the accessibility of the mobile technology for the students. Out of 109 students, 17 of them does not have access to smart phone or computer. Besides most schools in Bhutanese context restrict the use of mobile technology for the students due to various problems linked with it. As Kerawalla et al., [11] suggests, the teaching content should be flexible in order for AR to be successful. However this is not the case in our education system.

4. CONCLUSION

AR has become one of the most sought after futuristic model in teaching and learning domain. It is at the initial stage and there is a lot of opportunities for further explorations. With cheaper technologies available at our disposal, most students can afford smart phones that can be used as an important tool to experience AR. This study is also a result of exploration on the AR front. The results and findings from this study as well as from the literatures were encouraging. The frequencies of the ratings and mean scores for each statement explicitly indicated that both students and teachers have a positive attitude towards the use of AR in the teaching learning process. As our society delve into technology drive, it is an encouraging indication that Bhutanese students and teachers are ready to integrate AR through mobile technologies in their teaching learning experience. Yet attitude alone cannot suffice. Our teachers and students need platform and opportunities to engage in learning through AR tools more frequently in order to cultivate its benefits. More exploration on its effectiveness needs to be studied especially in Bhutanese context.

The findings suggest that the role of the wool model was largely determined by the pupils' prior knowledge about genes and DNA and that as the teachers were aware of the pupils' prior conceptions they adapted the model accordingly. The model was malleable and had multiple roles in learning for the pupils in the different years that reflected their developing conceptual understandings about genes and DNA. Rather than a domain general modelling capacity, the specific be an important factor that had an impact on the way that the model was used by the teacher and the pupils in the learning process. For the Year 2 pupils the use of the model provided a concrete image and the language to describe a mechanism for the known concept of inheritance. For the Year 5 (and some Year 9) pupils the model helped to develop an association between the concepts of gene, DNA, living things and inheritance. For Year 9 (and some Year 5) participants the wool model coalesced the divergent concepts of gene and DNA. Finally, for the Year 12 pupils, the model initiated and consolidated networks of understanding related to genetics concepts and preceded further network creation to protein synthesis and characteristics.

CONSENT

As per international standard or university standard, participant's written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX A

The following steps were used to develop and view the Augmented Reality experience.

1. Create a metaverse account in metaverse studio
2. Log in into account
3. Create experiences (Augmented Reality) on the concept to be taught (meiosis and genetic engineering).
4. Publish experiences. A QR code will be generated. (You can also share your experiences through links provided.)
5. Download 'Metaverse' app from App store or Google play and create an account similar to the account created in metaverse studio.
6. Scan the QR code by the App to view the experiences.

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