Improving Students' Collaborative Learning Experiences within a Game-Based Augmented Reality Learning Environment

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Abstracts: In today's post-COVID 19 world, the need to re-establish and strengthen collaborative activities is crucial in improving their learning experiences, and technology has become more prevalent as an enabler and a necessity to support this. Therefore there is a need for the development of student learning approaches that can capture their learning experiences and bridge the gap between formal learning and a more authentic, collaborative approach towards learning. Research has suggested that the use of emerging technologies such as Augmented Reality (AR) have been conducive in promoting better understanding of complex and difficult content in classes and offer learners the rich and engaging learning experience of visualizing course content, but have not yet been fully evaluated for their effectiveness in improving the learning experiences of students. As such, this study sought to design a game-based AR environment that investigated students' attitudes and perceptions of using game-based AR, within a Team-Based Learning (TBL) class structure in their learning process, and its impact on student learning experiences. 56 Undergraduate level students participated in this mixed method research study and in this game-based AR learning environment. Data was collected on their attitudes and triangulated to obtain the study's results. Findings showed that students were motivated to learn more, that the learning environment improved their collaboration, and were positive to having such learning experiences in their future courses, and a game-based AR learning framework, GALE, was presented. Such findings have important implications for the use of augmented reality as an instructional tool in 21st century learning environments.

Keywords: Augmented Reality, Game-Based Learning, Learning Experiences, Collaborative Learning, Team-Based Learning (TBL).

1. INTRODUCTION

As we move into the new norm of the post-pandemic educational landscape, technology has become an integral part of the acquisition of higher order thinking skills. These include innovation, creativity and communication skills. In addition to that, technology also enables learners to cultivate problem-solving and critical thinking skills which are much needed in 21st century workplaces. There is also a call for more authentic learning experiences that will culminate in more student engagement and active participation [1]. This is to address a growing issue of the lack of pedagogically sound learning environments that better engage learners, that appeal to their need for visually appealing learning experiences, and for more collaborative interactions with their peers.

Malaysian teaching methodologies have been criticised as becoming out of date [2], and that current classroom designs needed to be enhanced to support technology- enabled teaching strategies [3]. As such there is a need to design such learning spaces that would accommodate these new requirements of learning, ones that would provide effective engagements and good attention and retention rates [4].

Research in collaborative learning has found that individual learning is more disadvantageous to learners as they do not learn as much as they would in a group setting that promotes interactions among its members. By having peer-to-peer interactions, learners would be more inclined to actively participate in their learning process, establish more social relationships with their group members and better solve problems as a team. Research by [5] suggests that students working collaboratively as a team can cultivate higher confidence and understanding levels, and be better able to reflect on their own learning. In today's post-COVID 19 pandemic, the need to re- establish and strengthen collaborative activities is crucial in improving their learning experiences, and technology has become more prevalent as an enabler and a necessity to support this. Therefore there is a need for the development of student learning approaches that can capture their learning experiences and bridge the gap between formal learning and a more authentic, collaborative approach towards learning. According to [6],

game-based learning (GBL) has been shown to improve cognitive performance and visualisation of concepts. It has also been shown to enhance problem-solving and critical thinking in students and is growing prevalent in today's educational methodology. In addition, GBL has been shown to increase motivation and peer collaboration among students [7]. [8] posit that game-based learning can effect 4 areas of engagements within learners, which are:

1. Cognitive, where their understanding of the content and learning material is investigated

2. Motivation, which considers their level of engagement within the learning environment

3. Affective, which considers the level of enjoyment learners have in the learning environment

4. Socio-Cultural, which gauges their level of social interactions with their team members

However, despite its growing popularity in education, more research still needs to be done on their efficacy in cultivating positive learning experiences. While some studies have found strong relationships between GBL and the content taught, others have found insignificant relationships between them [9]. Much of this diverse findings may be due to the varying levels of guidance within the game environment. As such, there is still a need to investigate its effectiveness with respect to its context of use and the guidance that it provides the learners. In addition to the emergence of GBL as a learning methodology in the classroom, Horizon Reports of 2020 [10] and 2022 [11] have suggested that the application of Augmented Reality (AR) have been conducive in promoting better understanding of complex and difficult content in classes, and offer learners the rich and engaging learning experience of visualizing the course content. Through augmented reality technology, graphics, sounds and videos are superimposed over existing real-life environments, creating an extended reality and a richer learning context. As with game-based learning, AR technology has also been growing in popularity in education due to its ability to combine the real-world with virtual content and engaging students in practical and hands-on activities. Through AR, students can visualise complex content, manipulate virtual objects, and extend learning perspectives, enabling the learner to co-create content while learning. However, there is also a lack of studies on the use of AR in education and its effectiveness in improving the learning experiences of students, especially in the use of AR in game-based learning [12]. Recent research has shown that Team-Based Learning (TBL) has been effective as an instructional strategy for fostering collaboration among students. TBL is a student- centred pedagogical strategy that provides students with a learning structure that enhances their collaborative learning experiences and improves the quality of their learning through the flipped classroom approach. Developed by Dr. Larry Michaelsen in the 1990s, team-based learning (TBL) is defined as a group-based learning strategy that "... provides students with opportunities to apply conceptual knowledge through a sequence of activities that includes individual work, team work, and immediate feedback" [13]. In a TBL environment students initially work individually and then in groups to collectively solve problems and subsequently apply their conceptual knowledge into practice-based activities. TBL is characterised by 4 key components: 1) Individual pre-class preparations, 2) Individual and Team Readiness Assurance Tests (IRATs and TRATs), 3) Immediate and timely feedback from the instructor, and 4) Decision-based tasks to be performed in class by student teams. TBL has been shown to positively impact student learning outcomes and successfully applied in the healthcare, medical, business, engineering and other STEM-related fields [14]. Research has shown that TBL is more prevalently used in STEM-related fields but not so much in the creative multimedia and design fields and research is calling for its expansion into other non-STEM disciplines, lending its best practices to the improvement of student learning experiences within the creative and design fields [15]. Therefore, this study sought to investigate the effectiveness of game-based AR applications within a TBL environment and their impact on student learning expriences such as collaboration, teamwork and problem-solving. In particular, this research was guided by the following research question: "What are students' perceptions of a game- based AR learning environment?"

2. DESIGNING THE LEARNING ENVIRONMENT

The learning environment in this research study was designed incorporating the 4 key elements of Team-Based Learning [13]. Within this learning environment, the collaboration and group engagements were mapped to the TBL approach supported by game-based augmented reality activities. Table 1 shows how these game-based AR

activities were mapped to the team-based learning tasks.Figure 1 shows the game and AR learning applications, and Figure 2 presents one group's AR-based reimagined booth.

Table 1. The mapping of the class to the Team-Based Learning (TBL) components

TBL components	Game-based AR collaborative activities
IRAT (Individual Readiness Assurance Test)	Individual students were given a game-based IRAT application with 5 questions to be completed in 20 minutes.
TRAT (Team Readiness Assurance Test)	Students answered the same questions but in teams. Thesequestions were now provided to them in an AR environment where they competed with other teams to answer the questions within 20 minutes.
Clarification and Mini Lecture	A mini lecture was given by the lecturer to clarify the answers to the questions answered. This process would entail not giving the answers directly to the students but to probe each team to justify the choice of their answers as well as to rationalize not choosing the incorrect answers. This was to promote deeper thinking of their answers and demonstrate their problem-solving skills.
Implementation	Teams would then collaborate with each other to create an AR representation of their project booth for their project event (see **Fig. 1**). This would enable students to collaborate and demonstrate critical thinking and problem-solving skills with regards to a meaningful task.

Fig. 1. The game and AR applications presented to the students during the TBL session

Fig. 2. AR booths reimagined by one student group during the Implementation phase

3. METHODOLOGY

A convergent mixed method research design was used in this study, where both quantitative and qualitative data were collected and analyzed. Ethical clearance from the university was obtained and students were given consent to sign. Undergraduate students in the Faculty of Creative Multimedia, Multimedia University participated in this study. These were Final Year students taking a course on "Project Management". The course required them to work in groups to plan and execute an event based on the theme, "Making the world a better place" and guided by any one of the United Nations' SDG (Sustainable Development Goal) of their choice. The groups were given 14 weeks to conceptualise, plan, and execute their live event. To improve their collaborative engagements with the project, the course was structured following the TBL approach and supported by game-based and AR technologies as shown in Table 1. A total of 56 students consented to participate with 10 students opting out of the study and taking the survey. In addition to the survey and the research design, qualitative data in the form of student comments were solicited to provide more in-depth support to the survey findings.

4. ANALYSIS AND RESULTS

The survey administered was a 5-point Likert scale ranging from 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, and 5 = Strongly Agree. The survey sought to gauge the students' perceptions of collaborating within a game-based AR learning environment in the following constructs, as defined by Plass et. al, (2015). The data collected was analysed using SPSS17 and Table 2 shows the results of the survey and the students' comments.

Table 2. Survey results and the students' comments.

Items Cronbach Alpha = .969 (n=56)	Mean (m)	Percentage of positive responses
1. I found communication to be important for my group to succeed	4.29	91.1
2. I enjoyed collaborating with my teammates in the game	4.09	85.7
3. I will be able to apply what I've learnt to future projects	3.96	76.80
4. I was able to be in control of my own learning in the game	3.89	73.2
5. I am satisfied with my contribution to my group in completing this game	3.88	69.60
6. I felt that the group was able to achieve our goals in the game	3.86	73.20
7. Working as a team in the game allowed me to improve my problem solving skills	3.82	71.40
8. I felt that I can learn more when working with my team	3.82	71.40
9. I was able to collaborate well with my teammates to complete the game	3.82	69.60
10. I have more confidence now in my understanding of the topic	3.80	67.90

Findings from the survey showed that students were positive and highly reliable, as shown by Cronbach's Alpha reliability coefficient of 0.989, showing that the survey was a very reliable instrument. As seen in Table 2, survey results showed that students were able to engage in these 4 areas suggested by [8]. With regards to the Cognitive construct, 73.2% of students reported that they were in control of their learning (Item 4, m = 3.89) and 71.40% of students reporting that they were able to learn better when working in a team (Item 8, m = 3.82). This is further supported by their comments that, "I was able to learn new things and correct my mistakes", and "...helped me to learn new things". Students also reported positively about the Motivation construct, with 76.8% of students reporting that they were now able to apply what they learned in the game to future projects (Item 3, m = 3.96). 71.4% of

student reported that they were now able to improve their problem-solving skills from working together as a team in the game (Item 7, m = 3.82), 73.20% of students reported that, as a group, they were able to achieve their goals in the game Item 6, m = 3.86). This construct is also positively supported by their comments, stating that the game-based learning environment was, "Engaging and keep me focused", "Quite motivated because of my teammates", and "I think it involves more engagement which makes it entertaining".

With regards to the Affective construct, enjoyment and fun were reported positively for this learning environment. 85.7% of students reported that they enjoyed collaborating with their teammates when going through the game (Item 2, m = 4.09). 69.60%of students reported that they were satisfied with their contribution in the game (Item 5, m = 3.88), and 67.9% of students reporting that they now have more confidence in their understanding of the topic (Item 10, m = 3.80). Students' comments also provided strong positive support for their high level of affective engagement, as they commented that, "I like the fun that i felt when playing the games with my teammates… the vibes", "Fun to play with friends", "Make my study become fun and more innovative.", and "I think it is fun and a great activity for all the students. Better engagement, better learning, better understanding,". And with regards to the Socio-Cultural aspect of the learning environment, students reported strong evidence that being in a team-based setting enabled them to have positive learning experiences. 91.1% of students reported that working in a team enabled them to cultivate communication skills (Item 1, m = 4.29), and 69.60% of students reported that they were able to collaborate with their teammates in the game (Item 9, m = 3.82). This was also supported positively by their comments, as students commented that, "I think it helped us as a group communicate more as well as remember the question since we took time discussing them", "Having discussions with other team members helped to complete the game smoothly", "Build team spirit in the group" and "It was fun playing the same game with my group mates".

Overall, the survey findings showed that having the game-based AR learning activities within a team-based learning environment positively impacted the students' engagement, motivation, enjoyment and collaboration experiences in the class. Interestingly, in addition to positively supporting the 4 constructs of game-based learning, students also commented specifically on the game-based AR learning application and its support in their collaboration within the TBL structure. Table 3 presents some of their comments.

Table 3 Students' comments on the game-based AR application and the TBL learning environment.

Student comments on the game-based AR applications
1. *"The visuals for the AR…is very innovative and immersive"*
2. *"It's refreshing in a learning environment"*
3. *"The unusual, out of the box approach as opposed to traditional classes."*
4. *"The game design interface is impressive"*
5. *"Interactive game & discussion with team members"*
6. *"Collaboration with the team"*
7. *"They help me to do more critical thinking"*
8. *"The interface of the game and how interactive it was"*
9. *"Attractive visuals make learning less boring"*
10. *"The discussion and the enthusiasm of my group"*
11. *"We communicated and worked together on answering the questions"*
12. *"Because when we want to answer the questions, we would ask each other first, why we think our answers are right or wrong."*
13. *"It should be more game based courses because who doesn't like game and it should be a thing from now on where we can learn while playing games"*

As seen in Table 3, students found that game and AR applications supported their learning well, stating that, "The visuals for the AR…is very innovative and immersive", that "The game design interface is impressive", and that its "Attractive visuals...make learning less boring". They also commented that they liked "The interface of the game and how interactive it was", and that learning in this environment was "...unusual, out of the box approach as opposed to traditional classes", and commented that the interactivity of the game allowed them to experience "Collaboration with the team". The applications also provided them with the ability to communicate and work together with their team members during the TBL class, commenting that, "We communicated and worked together

on answering the questions… Because when we want to answer the questions, we would ask each other first, why we think our answers are right or wrong." It was also evident from their comments that the "Interactive game & discussion with team members" were some of the features that they enjoyed in the learning environment, as well as "The discussion and the enthusiasm of my group". Such collaboration and teamwork resulted in newly acquired skills, as students comment that "They help me to do more critical thinking". Overall, students showed positive acceptance of a game-based AR learning environment supporting the TBL structure, commenting that this was "... refreshing in a learning environment" and contending that "[there] should be more game based courses because who doesn't like game and it should be a thing from now on where we can learn while playing games". These comments provide very encouraging support for using games and AR in TBL structured classrooms to improve teamwork and collaboration among students as well as enhancing their engagement with the learning content.

5. DISCUSSION

In order to answer the research question, "What are students' perceptions of a game- based AR learning environment within a TBL structure?", a game-based AR learning environment was designed, underpinned by the TBL instructional strategy, to investigate their impact on student learning experiences, namely their collaboration, teamwork and problem-solving skills. Findings from the study show the following:

1. **Pedagogical outcomes**: The game-based AR learning activities within the TBL environment was effective in improving student engagement and participation in their learning process, consequently resulting in more positive learning experiences. By structuring the classroom environment to follow the instructional methodology of TBL, team collaboration and active participation was possible, and even improved, increasing their attention and retention levels. This is consistent with research findings by [3] and [10], and contributes a possible solution for the issue posited [15].

2. **Affective outcomes:** Student teams had fun and enjoyed the immersive and interactive game-based AR activities. By supporting the TBL environment with game-based AR activities, the learning environment was perceived to be more fun, innovative and interactive, which resulted in students being more motivated to participate and learn more about the topic, supporting the research by [8].

3. **Visualisation outcomes:** Students were better able to visualise their project concepts through the AR activity. This was evidenced by their reimagined AR booths completed during their Implementation phase in the TBL session. The AR technology enabled students to go beyond the physical classroom setting into the virtual one and acquire richer and more meaningful content without leaving the classroom. This is consistent with the findings of [11] about the benefits of using AR in the classroom.

4. **Group-based collaborative outcomes:** Collaboration and teamwork were positively enhanced both through the game and AR technologies, and through the TBL structure. Deeper reliance on teamwork to complete the assigned task, and a more synergistic implementation of concepts through group decision-making was evident among the groups, resulting in richer and more meaningful learning outcomes.

Based on these findings, the Game-based AR Learning Environment learning framework, GALE, is presented (see Figure 3).
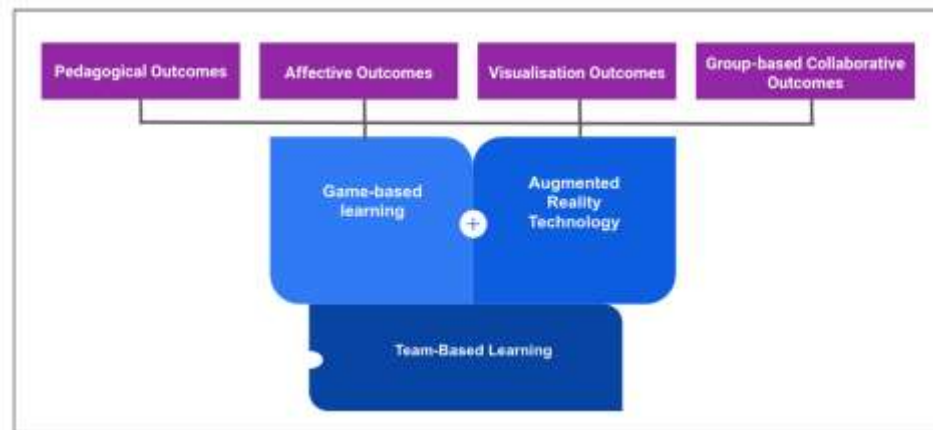
Fig. 3. The Game-based Augmented reality Learning Environment (GALE) learning framework

As can be seen in Figure 3, the framework is underpinned by the TBL instructional strategy as a means to redesign the class and prepare the learning environment to become more collaborative. With this strategy in place, game-based learning and AR technologies are incorporated into the TBL activities, resulting in the 4 learning outcomes, pedagogical, affective, visualisation and group-based collaborative learning. With an effective implementation of this framework, students' learning experiences can be improved, especially in the areas of collaboration, teamwork and critical thinking. The findings in this study have indicated that this learning framework can be a positive guide for educators seeking to create more interactive and immersive learning experiences for their students in today's classrooms.

CONCLUSION

Guided by the lack of evidence of the effective use of GBL and AR technologies in education, and the lack of TBL studies in the creative design fields, this research has shown that redesigning the learning environment using the TBL approach has been effective in providing students with deeper and meaningful collaborative learning experiences. When this structure is further supported by technologies such as game-based learning and Augmented Reality, the learning experiences become more immersive and interactive, and students become more active and engaged in the learning process and enjoying the learning process. These findings and the GALE learning framework provide positive support for the use of GBL and AR activities in the classroom for 21st century learning.

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