Eliciting student engagement of students developing XR applications via implementation of PBL

Khadija Hamidani [1] Tse-Kian Neo *[1] Vimala Perumal [1]
Angela Amphawan [2], Ade Iram Susanty [3], Mahir Pardana [3] and Sherly Artadita [3]
[1] Faculty of Creative Multimedia, Multimedia University, Malaysia
[2] Smart Photonics Research Laboratory, School of Engineering and Technology, Sunway University, Malaysia
[3] School of Communication and Business Telkom University, Indonesia

*Corresponding author: tkneo@mmu.edu.my

Abstract. Recently, the growth and demand of Extended Reality (XR) Technologies, which include (AR), VR and MR) around the world have surged, as XR is being utilized in a wide spectrum of fields. Many higher education institutions (HEIs) are integrating XR Technologies in their classrooms to increase learners' interest and provide them immersive simulated learning experiences using AR and VR educational applications. To meet the increasing demands of immersive technology applications, many HEIs are incorporating creative multimedia undergraduate programs to empower immersive technologies applications developers with the required professional skill set. However, one critical issue that most of the students developing immersive AR and VR applications face is the low level of student engagement (SE) due to the time-consuming process of development as well as implementation of passive teaching approaches. Constructivist student centered learning approaches over the years have shown influence on the multimodal construct of SE which encompasses behavioural, cognitive, and emotional engagement. Conducive to elicit SE levels of n=26 students enrolled in Bachelor of Creative Multimedia program developing final year AR & VR projects, a preliminary survey research was conducted to investigate the impact of constructivist Project Based Experiential Learning approach on student engagement. The results of the study indicate a significant impact on all three domains of student engagement of learners developing XR applications. The results indicated that students found the Project-Based Learning classes to be engaging and created a positive attitude amongst the students.

Keywords: Experiential Learning, Project Based Learning, Extended Technology (XR), Student Engagement.

1 Introduction

During the last few years, the utilization of immersive technologies is gaining momentum in different fields and industries across the globe. Mainly, the Extended Reality (XR) Technologies, which include Augmented, Virtual, and Mixed Reality

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technologies are rapidly evolving and expanding in the medical, STEM education, engineering, entertainment, advertising, and other training and innovation sectors for the past few years due to the pandemic [1]. As a result, there is a high demand for immersive technology applications [2] and many HEIs are integrating multimedia bachelor programs and courses to educate and provide training to future creative content developers and designers [3]. However, a critical issue faced by students developing immersive applications is of low level of student engagement and motivation since the process of development is time-consuming and teacher-centred learning environments and passive teaching approaches often disengage learners [4]. Student Engagement plays a crucial role in the academic success of learners in higher education institutions (HEIs). It is widely recognized as key to enable learners to acquire a wide range of 21st-century skills which are a necessary requirement for professional workplace environments [5].

Student-centered learning environments and teaching approaches like experiential learning and project-based learning environments have often been shown to improve learners' engagement levels. Kolb's Experiential Learning theory supports the notion of learning through experience, while likewise project-based learning elements enable learners to solve real world problems and create content collaboratively [6]. Further research is suggested by [6], to investigate the impact of project based experiential learning (PBEL) on student engagement of learners.

To elicit student engagement of multimedia students, this preliminary study investigates and identifies the pedagogical impact of PBEL on student engagement of learners developing XR technology applications.

2 Literature Review

2.1 Student Engagement

The multidimensional construct of student engagement shows an overlapping of three types of engagements, namely behavioral, cognitive, and emotional engagement, with one another [7]. Each engagement is associated with the learning domains which include cognitive, affective, and psychomotor domains. Each engagement has its own indicators, which when elicited improve the overall student engagement of the learners as all three types of engagement are interconnected. For example, increased motivation, which is an indicator of cognitive engagement according to [7], positively impacts behavioral and emotional engagement, as it allows learners to participate actively in and out of class as well as, provides them a sense of belonging. Students who are cognitively and affectively engaged in the learning process are more likely to rapidly acquire 21st century skills through experiential learning.

Different 21st century skills are required by creative content designers as new paradigms of immersive technologies are evolving[8]. 21st century skills are also known as transversal skills which require continual development for different competencies. The domains of transversal skills required by immersive technology designers and developers include creativity and innovation, adaptability and flexibility, digital literacy, technical aptitude, written and verbal communication, project management, teamwork and collaboration, leadership and initiative, critical thinking and problem solving, and professionalism [9].

By integration of effective constructivist pedagogies and student-centered learning environments such as experiential learning approach and project-based learning method, student engagement is elicited. Engaged learners think critically, propose creative solutions, and innovative ideas to solve real-world issues [10]. They are eager to research and analyze new information, collaborate and contribute to teamwork, communicate effectively, explore, learn, and use different resources and new digital tools.

2.2 Project Based Experiential Learning

The approach of Project Based Experiential Learning stems from David Kolb's Experiential Learning Theory and its method of project-based learning. Experiential Learning theory illustrates the continuous learning process across four stages of concrete experience, reflective observation, abstract conceptualization, and active experimentation [11]. Concrete experience and reflective observation stimulate learners' senses and prior knowledge and cognitively engage them to make connections between new and prior knowledge and think critically about the proposed real-world problem [11]. Learners are able to reflect on their new experience or the given problem and, through collaboration and sustained inquiry practices, they try to search for solutions. Abstract conceptualization elicits cognitive engagement and enables learners to develop concepts and theories based on concrete experiences. By active experimentation learners can apply their ideas and create prototypes to solve the given problem [11]. All four stages of experiential learning are supported by project-based learning elements to elicit student engagement [12] throughout the four stages of project management life cycle. The project-based learning method consists of elements which include, challenging problem or question, sustained inquiry, authenticity, critique and revision, student voice and choice, constant feedback and reflection and a public product [12]. These elements are integrated across the four phases of a typical project management cycle.

Project-based experiential learning propels and directs the learning experience throughout the learning process and engages learners to attain different transversal skills. By solving a real-world problem students develop the skills of doing research, analysing, and organizing the information to propose and create innovative solutions [13]. Through this practice of sustained inquiry students' cognitive engagement is elicited and their problem solving, and critical thinking skills are improved [14]. This impacts their behavioral and emotional engagement as well as motivates them to actively participate in the learning process. Similarly, the element of student voice and choice improve the learner agency and elicits their emotional engagement by allowing them to share their ideas and implement them in the project. This positively impacts their participation in classroom and cognitively engages them to opt for deeper learning practices [14]. Additionally, reflective observation and constant feedback and reflection allow learners to improve their prototypes and product and impacts all three constructs of student engagement. Positive feedback motivates learners, enhancing their cognitive and emotional engagement, and eliciting their behavioral engagement to interact with their peers and facilitators [14].

Students developing XR applications via project-based experiential learning process are more likely to be engaged, as they try to solve authentic real-world problems through sustained inquiry, collaborating with peers and devising creative and innovative ideas.

2.3 Incorporating XR Technologies in Education

Integration of XR Technologies in higher education institutions is becoming increasingly popular as these immersive technologies allow students to learn complex theories and solve problems through innovative ways by providing them hands on learning experience and developing their valuable skills [15]. XR technologies comprise mainly Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) technologies. While many institutions are using AR & VR simulations to provide learners opportunities to practice and develop their skills, such as in medical and architectural education, there are also many institutions which are offering immersive technology courses to train and educate learners to develop and design immersive experiences [16].

By interacting with XR Technologies, students are more likely to be engaged in an active learning process. Through hands-on interactive learning approaches, students can interact with and manipulate virtual objects in simulated immersive environments [17]. These can help improve their ability to understand complex concepts and provide them with multisensory experiences. XR Technologies provides visual, auditory, and even haptic feedback, which is prone to enhance learners' engagement levels, captivate their attention, and motivate them to actively participate in learning activities [18]. The user experience factors of using XR Technology devices such as VR headsets, HMDs, Microsoft HoloLens, Magic Leap, and other mobile and wearable devices have shown to impact student engagement domains [18]. User experience factors including simulations, novelty, presence, embodiment, and interactivity have an impact on students' cognitive, affective, and psychomotor domains of engagement [19].

By creating XR experiences, students can collaborate with one another to solve problems and improve their teamwork and communication skills in the process [20]. The opportunities provided by XR technologies are boundless, and as it evolves, students in higher education institutions are expected to experience more innovative uses of XR and develop their digital literacy and technical skills.

3 Method

This preliminary study was conducted using a survey research design as it allows researchers to obtain precise results, with good statistical significance, in the most convenient manner which can be generalized to the larger population [21]. A total of n=26 students enrolled in the final year of undergraduate program of BSC Hons in Multimedia Technology and Bachelor of Multimedia (Hons) Virtual Reality, participated in this study. The subjects were invited to participate in this study using purposive and convenient sampling methods. The combination of purposive and convenience sampling methods offers an effective way for researchers to obtain large quantity of data which can help describe the major impact on population, of the findings [22]. Written consent was obtained from all participants prior to data collection using a close ended 5-point Likert scale survey questionnaire which was adapted from the works of [23] and [24]. The survey was divided into four sections with four items related to each type of engagement and four items related to the outcomes of student engagement. The survey was administered after completion of students' final year project to investigate the impact of PBEL on student engagement levels of learners creating XR applications. Results were analyzed using descriptive statistics and reliability test was conducted using Cronbach alpha test.

4 Results

Descriptive Statistics analysis was conducted to present the following results of the 5-point Likert scale survey questionnaire with means and standard deviation of each item and the internal validity of the three main constructs of student engagement namely behavioral, cognitive and emotional engagement.

4.1 Cognitive Engagement

Table 1. Cognitive Engagement Results

Items	Mean	Standard Deviation
Item 1	3.92380	.688365
Item 2	4.1923	.63367
Item 3	4.0385	.72004
Item 4	4.1538	.67482

As can be seen in Table 1. cognitive engagement of learners appeared to be elicited during the development of XR projects. Item 1 shows that despite working on the project remotely, students felt excited to attend this course (M= 3.92308). Item 2 shows that to meet the expectations of facilitators and stakeholders, students worked diligently on their projects, (M = 4.1923). During the project, the students adopted the practice of sustained inquiry and asked meaningful questions to solve the given problem (M=4.0385). Likewise, they opted for deeper learning practices by searching for relevant resources to resolve the real-world problem (M =4.1538). These numbers suggest that PBEL had impacted students' cognitive engagement significantly, as motivation, engaging in deeper learning practices and persistence are indicators of cognitive engagement. Increased cognitive engagement improves learners critical thinking and analytical skills as well as impacts their behavioral and emotional engagement by enhancing their interaction and participation in class.

4.2 Emotional Engagement

Table 2. Emotional Engagement Results

Items	Mean	Standard Deviation
Item 1	4.1154	.71144
Item 2	4.1538	.67482
Item 3	4.4615	.58177
Item 4	3.7692	.90808

Table 2. shows results of emotional engagement of learners due to the implementation of project based experiential learning. The results indicate that students were able to share their ideas and collaborate on the project with their peers (M=4.1154). Students (M = 4.1538) were actively able to contribute their skills and ideas towards the planning of the project. Similarly, a significant number of students (M=4.4615) contributed their skills and ideas towards the implementation of the project. The observed decrease in Item 4 (M=3.7692) can be interpreted as rejection of students' ideas by project facilitators and stake holders during critique sessions, made very few students feel that their ideas and views were appreciated.

Overall, from the results it can be interpreted that PBEL had a significant impact on emotional engagement of the learners developing XR technologies. The project-based learning's element of student voice and choice allows learners to collaborate and share their ideas and skills towards the planning and implementation of the immersive application development process. Increased emotional engagement enables learners to improve their emotional intelligence, empathy and regulation skills and teamwork skills which are vital for professional working environments. Additionally, elicited emotional engagement also positively impacts learners' cognitive engagement as it motivates as well as encourages them towards solving challenging tasks.

4.3 Behavioral Engagement

Table 3. Behvioral Engagement Results

Items	Mean	Standard Deviation
Item 1	3.6923	1.04954
Item 2	4.1923	.74936
Item 3	3.9231	.68336
Item 4	4.1154	.71144

The results presented in table 3. show varied results of behavioral engagement. Very few participants agreed with Item 1, that they were able to discuss the progress of the project with their facilitators (M=3.6923). This decrease was more likely because of lack of proper communication and limited response to the students from lecturer. A significant number of students on the other hand did discuss the progress with their group mates (M=4.1923) which can be interpreted as that the students felt more comfortable, as reaching their peers was easier and felt it was more important to discuss their progress with their team as lecturer was often non-responsive to emails and unavailable during Covid19. Apart from that most of the students agreed that they listened to and respected the ideas of one another (M=3.9231) and interacted with the course content in a variety of different ways using different resources and tools (M= 4.1154).

From the results shown in table 3 it can be inferred that PBEL had a mixed impact on behavioral engagement of the learners. Through interaction with their peers and content, students were able to construct knowledge and they effectively developed their teamwork and communication skills. Interaction with peers also improves students' emotional engagement as learners feel more at ease to share their ideas and skills in the development of the project. Additionally, interaction with content also positively impacts students deeper learning practices which elicits their cognitive engagement as well.

4.4 Student Engagement Outcomes

Table 4. Student Engagement Outcomes Results

Items	Mean	Standard Deviation
Item 1	4.1923	.74936
Item 2	4.3846	.63730
Item 3	4.0385	.72004
Item 4	4.1538	.61269

The results in Table 4. represent the outcomes of student engagement which were achieved by students during the project development. Many students reported that they acquired and developed knowledge and professional skills related to future XR technologies jobs (M=4.1923). The majority of the students agreed that the project helped them to think analytically and critically (M= 4.3846). Item 3 (M= 4.0385) shows that students developed soft and hard skills and many of the participants learned how to manage projects professionally in the future (4.1538).

It can be inferred from the results in table 5, that all three types of engagement enable learners to attain 21st century skill set. Increase in cognitive engagement improves students critical thinking, problem solving and analytical skills. It also enables them to acquire knowledge and technical skills through interaction with the content, their peers and their facilitators and experts in the field. Students are also able to acquire a wide range of professional skills such as teamwork skills, communication skills, project management skills, and interpersonal and intrapersonal skills through elicited emotional and behavioral engagement levels.

4.5 Student Engagement Outcomes

A reliability test of Cronbach Alpha **α** was conducted on the survey items for each construct which showed the following results:

Table 5. Cronbach Alpha Results

	α
Cognitive Engagement	0.660
Emotional Engagement	0.633
Behavioral Engagement	0.746

Student Engagement was divided into 3 constructs of Cognitive Engagement, Behavioural Engagement and Emotional Engagement with 4 items designated to each construct. Internal Reliability Cronbach Alpha test was conducted for each construct. Results showed that alpha for Cognitive Engagement was equal to 0.660 which is a satisfactory result. For Behavioral Engagement alpha was equal to 0.633 and for Emotional Engagement result was 0.746. Cronbach Alpha coefficient value between 0.4 - 0.8 is considered adequate [25], hence the result of the reliability test (in Table5) shows a satisfactory reliability value and internal consistency for each construct. Further improvement can be achieved and determined by increasing the number of items for each construct.

5 Conclusion

Overall, this preliminary study results suggest that through the implementation of project based experiential learning there was a significant but varying impact on student engagement of learners developing XR technologies. The results emphasize the importance of student-centered learning environments to elicit student engagement of learners which can help them acquire a 21st century skill set to excel in the professional field of immersive technologies. Considering that the field of immersive XR technologies is growing rapidly, HEIs can implement PBEL as a pedagogical model to upskill their learners. By implementation of PBEL future professional designers and developers of XR immersive technologies can create numerous virtual simulation solutions to solve real world problems across different fields and industries. This is an ongoing study and has set future research directions to enable researchers to gain more insight about the pedagogical impact of PBEL on student engagement of learners enrolled in immersive technologies educational courses.

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