Nurturing Inquiring Mind Through the Quest of Augmented Reality: An Experiential Learning Approach

Norphealey Eang, King Mongkut's Institute of Technology Ladkrabang, Thailand
Sirirat Petsangsri, King Mongkut's Institute of Technology Ladkrabang, Thailand
John Morris, King Mongkut's Institute of Technology Ladkrabang, Thailand

The Asian Conference on Education 2023
Official Conference Proceedings

Abstract
Nurturing students' inquiring minds is essential as it encourages curiosity and critical thinking, both of which are tools for independent learning and problem-solving. In this study, we examined the effects of AR-Quest activities integrating with the experiential learning approach on undergraduate students' inquiring minds. Thirty Thai undergraduate students participated in the study, which spanned a three-week period, where students were asked to do AR quests. The AR quests were designed to be inquiry-based, fostering students' discovery, collaboration, and reflection. The AR quests encompassed a confirmation quest, a discovery quest, and a collection quest. We used a 5-point Likert scale survey questionnaire to collect data on the students' curiosity, critical thinking skills, and willingness to explore new ideas. Descriptive statistics was employed to calculate mean scores and standard deviation. The findings revealed that the AR-Quest activities stimulated the students' curiosity, promoted their critical thinking, and enriched the learning experience. Additionally, the findings suggested that the experiential AR activities could foster an engaging learner-centred environment that encouraged exploration, questioning, and discovery. In this regard, integrating experiential learning with AR technology facilitated a shift from a conventional classroom paradigm to a more dynamic, interactive learning regime, making learning meaningful and nurturing students' inquiring minds. However, in future studies, researchers/educators are recommended to consider a controlled group comparison to provide a comparative baseline to measure the effectiveness of the experiential AR-Quest activities.

Keywords: Augmented Reality (AR), Experiential Learning, Inquiring Mind

Introduction

Teaching and learning processes should inspire and captivate students' minds and imaginations (Pugh & Girod, 2007). McDougall (2014) states that students achieve their best in learning when they are involved in the learning content and focus on the subjects being learned. In experiential learning, practical learning activities form the core of meaningful learning experiences (Itin, 1999). This engagement unfolds across various levels of student participation (Hawtrey, 2007).

In traditional teaching approaches, having students explore learning quests usually ends with boring learning (Warda & Mohammed, 2016). However, learning quests where experiential learning and augmented reality are integrated can improve student engagement in learning activities (Carmigniani & Furht, 2011; McDougall, 2014). By providing students with hands-on experience related to the learning content, students, experiential learning and augmented reality facilitate a more meaningful and impactful knowledge learning (Masood & Egger, 2019; Yardley, Teunissen, & Dornan, 2012).

Lessons integrated with experiential learning and augmented reality technology can engage students more than many traditional lessons do (Gopalan, Bakar, & Zulkifli, 2017; McDougall, 2014). Combining the two approaches encourages students to look deep into what they are learning and critically apply, analyze, synthesize, and evaluate what they learn (Carmigniani & Furht, 2011; Haynes, 2007). The experiential augmented reality approach transforms the learning environment into a dynamic space that fosters inquiry-based learning, enabling students to develop and refine their inquiring minds. (Cannon & Feinstein, 2014; Carmigniani & Furht, 2011).

When lessons are experiential, situated, authentic, and contextual, the learning will be evocative, germane, memorable, and entertaining for students (Hawtrey, 2007). Consequently, these improve students' learning outcomes and encourage them to develop their inquiring mind of the love of learning (McDougall, 2014). In this paper, we explored how augmented reality quests based on the experiential learning approach can promote student inquiring minds.

Literature Review

Experiential Learning in Education

Experiential learning is a dynamic, student-centered approach that promotes active engagement, critical thinking, and problem-solving skills (Yardley et al., 2012). It plays a crucial role in education by providing students with hands-on, real-world experiences that enhance their learning and development (Haynes, 2007; Yardley et al., 2012). Experiential learning can engage students in learning, moving beyond passive listening and reading. This pedagogical approach encourages active participation in activities, experiments, and real-world simulations (Yardley et al., 2012), fostering deeper understanding, critical thinking, and problem-solving skills (McDougall, 2014). The shift from passive reception to active engagement represents a fundamental aspect of experiential learning, aligning with educational concepts emphasizing the importance of hands-on involvement in the learning process (Choi & Hwang, 2017). Moreover, experiential learning strongly emphasizes the practical application of knowledge and skills (Murphy, 2007). When students are provided with opportunities to transfer theoretical concepts into real-world situations, this approach

enables them to perceive the relevance and practicality of their academic pursuits. Applying knowledge in practical contexts enhances students' problem-solving abilities and facilitates bridging gaps between theoretical understanding and real-world implementation (Yardley et al., 2012).

Augmented Reality in Education

AR technology has gained significant attention in education due to its ability to create interactive and immersive learning environments (Masood & Egger, 2019). By overlaying digital content onto the real world, AR enhances students' understanding of abstract concepts and promotes active learning (Carmigniani & Furht, 2011). Previous studies have demonstrated the effectiveness of AR in various educational domains, including science (Gopalan et al., 2017), mathematics (Bujak et al., 2013; Estapa & Nadolny, 2015), and language learning (Eang & Na-Songkhla, 2020).

However, integrating augmented reality in education comes with certain challenges. One of the primary challenges is the cost and accessibility of AR devices and software (Rabbi & Ullah, 2013). Content development poses another challenge, requiring teachers to ensure alignment with learning objectives and provide meaningful learning opportunities (Lee et al., 2021). Technical considerations, including connectivity and device compatibility, must be addressed to ensure seamless implementation (Masood & Egger, 2019). Ethical and privacy concerns, especially relating to the collection and analysis of student data, represent additional dimensions warranting careful consideration in the implementation of AR technologies in educational settings (Bodkhe, Verma, Saraswat, Bhattacharya, & Tanwar, 2022).

Inquiring Minds via Experiential Learning

Houle (1961) is the first person to explain adult learners' motivation for learning and learning outcomes in non-formal education. His famous book, The Inquiring Mind (Houle, 1961), published concepts about adult education and self-learning basics. Houle describes many features of adults in informal learning activities. For example, each student is committed to what they learn, has educational goals, is happy with the learning process, and sees the value of education (Houle, 1961). In addition to research on the learning characteristics of adults, Houle classifies students into three groups:

1. Goal-Oriented Learners: this group of students will use education to achieve their goals. They believe education is a way to solve problems and respond to their interests.
2. Activity-Oriented Learners: this group of students will participate in activities or do things of interest to them in the learning context. This group will admit directly that they come to study for reasons other than learning.
3. Leaning-Oriented Learners: this group of students will participate in activities to learn about what they have in mind. They are committed to learning activities and see education as fun. This group of students can guide themselves to learn better than other groups.

Houle (1961) believes that experiential learning is one effective method used in promoting students' inquiring minds, which can engage students in the lessons by using experiences as the primary approach to learning. Lessons where there is the integration of an experiential

learning approach foster student inquisitiveness and nurture their inquiring mind, allowing them to get on well with the technologically driven world (Houle, 1961).

Nurturing Inquiring Minds Through Augmented Reality

There are few research studies on using AR-Quest activities to nurture students' inquiring minds. However, it is interesting to look at how the quest activities with AR technology shed light on this field. AR-Quest activities can be designed to confirmation quests that allow students to validate or confirm existing knowledge or concepts (Eang, 2019). These quests allow students to apply their prior knowledge and verify its accuracy through interactive AR experiences. By engaging in confirmation quests, students can deepen their understanding of concepts and develop confidence in their knowledge (Hill & Knutzen, 2017). Nurturing students' inquiring minds can also be done through discovery quests, designed to foster curiosity, exploration, and independent learning (Supratman & Wahyudin, 2021). These quests encourage students to investigate and discover new knowledge or concepts through AR experiences. Discovery quests promote active engagement and critical thinking as students explore virtual environments, analyze information, and make connections between different concepts (Kaur & Kauts, 2018). Collection quests can also be used to nurture students' inquiring minds. This type of quest usually involves students gathering and organizing information or objects related to a specific topic or theme (Eang, 2019).

AR-Quest Framework

Eang and Na-Songkhla (2020) developed an AR-Quest framework for teachers to adapt to design interactive and effective language learning. Table 1 gives a brief summary of the framework.

Table 1. Overview of AR-Quest Framework by Eang and Nasongkhla (2020)

Characteristic
• Learning activities are inquiry-based. • Students learn together in a semi-structured approach. • Learning activities are linked with real situations, and students learn by experiencing them. • Authentic learning tasks promote both students' social and physical engagement. The authentic learning experience is promised.
Grounded theories
• AR-Quest Model is based on experiential learning theories and inquiry-based learning theories.
Process
• *Analyze objectives*: objectives are what keep teachers on the right track. To analyze learning objectives, the existing curriculum and syllabus are to study. • *Analyze the context*: teachers determine who the students are and also identify the learning context. • *Plan*: teachers need to be clear with the learning objectives and determine learning resources that students will need to solve the quests. • *Prepare*: teachers prepare resources and other necessary tools and make sure everything is in place when needed to be used. • *Design*: script the learning activities based on the ideas and preparation from the previous steps.

• *Facilitate*: teachers hold back to give students assistance to complete answers to their questions. Instead, teachers help students through quest exploration and encourage to discover the solution on their own. • *Evaluate*: teachers use the assessment techniques/tools which are planned in the earlier steps. Students' learning progress can be assessed in discussion and reflection sessions.	
Resource	**Assessment**
• Learning resources are to be well-prepared before the quest discovery. • Primary resources for AR-Quest activities include worksheets, AR materials (AR markers), and AR mobile application.	• Assessment tools for the quests of augmented reality vary to each quest's design. Students can be assessed by observation and tests.
Teacher's role	**Students' role**
• Teachers explain the purpose of experiential learning to students. • Teachers are less dominant in the AR activities classroom. • Teachers promote authentic learning experience positively. • Teachers provide a situation or an experience that attract students' interest. • Teachers link learning objectives with authentic situations or experiences. • Teachers provide students any helpful resources to help students solve the AR quests. • Teachers allow students to explore, investigate, and uncover answers on their own.	• Students have their hands on practically authentic problems. • Students are involved in difficult and challenging tasks while exploring the AR quest. • Students are given freedom in the whole learning process if they make positive progress. • Students do self-evaluation on their learning progress. • Students learn from challenging tasks and become willing to change. • Students form new knowledge from the learning activities.

Methodology

Sample

The study involved a sample of thirty Thai undergraduate students who participated in a three-week exploration of AR-Quest activities. The students were exposed to experiential learning approaches integrated with augmented reality (AR) technology through confirmation quests, discovery quests, and collection quests.

Procedure

This research study lasted for three weeks, with 3 hours each. Before introducing the treatment, the students were asked to complete a self-evaluation survey questionnaire. In each week, students were introduced a new AR-Quest activity. In the first week, a confirmation quest was introduced to the students. The quest was a vocabulary verification activity where students used the mobile with AR application installed to scan printed images (markers) related to specific vocabulary words. The AR application then provided audio and/or visual cues to confirm the correct pronunciation and meaning of the words. This interactive experience allowed students to validate their Khmer vocabulary knowledge and reinforce their understanding of word meanings and pronunciation.

In the second week, they were asked to complete a discovery quest. This quest was designed to encourage students to explore the linguistic connections between Khmer and Thai, sparking curiosity about the similarities and differences in vocabulary. In this discovery quest, students were to analyze linguistic patterns and connections, requiring critical thinking skills as students later on reflected on the shared and distinct characteristics between the two languages. The quest also promoted a willingness to explore linguistic diversity and cultural connections, fostering an open-minded approach to language and communication.

In the last week, the students were asked to complete a collection quest. Students were required to listen to audio and observe 3D models representing Khmer words for stationery tools. To complete the worksheet, they needed to apply critical thinking skills to match the Khmer words with their Thai equivalents. The use of AR technology added a dynamic and interactive element that made the learning experience more enjoyable and fostered a positive attitude toward exploring new concepts.

After the last session, the students were administered the same survey questionnaire used to compare with their previous questionnaire data.

Figure 1: Students are doing AR-Quest activities.

Research Instrument

The research instrument for data collection in this study was a self-evaluated questionnaire. The questionnaire consisted of three independent sections, including 1) curiosity, 2) critical thinking, and 3) willingness to explore new ideas, with five items each to assess students' inquiring minds.

Data Collection

The data from the questionnaire during the pre- and post- treatment were calculated to find the mean and standard deviation (SD). Then, the paired sample t-test was used to examine the changes in students' inquiring minds before and after the treatment.

Results and Discussion

In this study, we used the T-test analysis to assess the impact of the AR-Quest activities on the students' perceived inquiring minds. Thirty participants were involved in the study, and the paired differences between pre- and post-treatment self-assessment scores were examined.

Table 2. T-test results of the students' inquiring minds before and after the intervention

Self-Assessment	N	Paired Differences		Sig
		Mean	SD	
Post – Pre	30	5.466	1.105	0.001*

Based on Table 2, the mean was 5.466, representing the average change in students' self-assessment scores, with a standard deviation of 1.105, indicating the variability among participants, with the p-value of 0.001, indicating a highly significant difference in students' perceived inquiring minds after engaging in the AR-Quest activities. This suggests that the AR-Quest activities were effective in fostering students' inquiring minds.

Table 3. Inquiring Mind Components

Pair (Post – Pre)	N	Paired Differences		Sig
		Mean	SD	
1 Curiosity	30	1.700	1.022	0.001*
2 Critical Thinking	30	2.100	0.711	0.001*
3 Willingness to Explore	30	1.666	1.061	0.001*

The research findings, as presented in Table 3, provide a detailed examination of the impact of AR-Quest activities on specific components of the students' inquiring minds. While Table 2 initially indicated a potential improvement in the students' inquiring minds, Table 3 delves into the nuances by investigating the three key elements: Curiosity, Critical Thinking, and Willingness to Explore.

Regarding the curiosity component, the mean paired difference of 1.700 indicates a significant increase in students' self-perceived curiosity following the engagement in the experiential AR-Quest activities, with a p-value of 0.001, providing strong evidence that these activities effectively fostered curiosity among participants. This aligns with foundational principles of experiential learning, as argued by Huang (2019) and Moorhouse, tom Dieck, and Jung (2019), who argue that hands-on experiences and active engagement by augmented reality promote curiosity by encouraging students to explore and question their surroundings.

Examining critical thinking, the mean paired difference of 2.100 signifies a substantial improvement in the students' critical thinking skills from the experiential AR-Quest activities, with a p-value of 0.001. This indicates that the experiential AR-enhanced learning activities positively contributed to the development of critical thinking among students. This finding supports prior research highlighting the benefits of experiential learning activities in fostering critical thinking skills, as emphasized by Rogers et al. (2023) and Huang (2019), who argue that experiential learning creates authentic environments requiring students to apply critical thinking skills in problem-solving tasks.

Lastly, regarding the willingness to explore, the mean paired difference of 1.666 indicates a noteworthy increase in students' openness to exploring the subject matter, with a p-value of 0.001. This emphasizes the positive impact of experiential AR-Quest activities on fostering a sense of exploration among the students. The perceived improvement in students' willingness to explore aligns with experiential learning literature, emphasizing the importance of hands-on experiences in promoting openness to new ideas and experiences, as articulated Konak, Clark, and Nasereddin (2014) and Huang (2019).

Conclusion

The research findings offer valuable insights into the transformative potential of experiential learning and augmented reality (AR) in fostering student inquiring minds. The integration of AR technology with experiential learning approaches emerges as a promising approach for teachers, providing a dynamic and learner-centric framework that nurtures active and inquiry-based learning.

The observed statistically significant improvement in the students' inquiring minds underscores the effectiveness of the experiential AR-Quest activities in fostering a holistic development of students' cognitive abilities. These findings carry implications for teachers and curriculum developers as they emphasized that augmented reality, when incorporated into learning experiences, presented a valuable opportunity to transcend traditional teaching methods. By recognizing the potential positive impact of AR-Quest activities, teachers can design innovative learning experiences that captivate students' interest and stimulate their inquiring minds.

Recommendations

This study employed a one-group pre-test and post-test design involving a 3-week intervention. For future research studies, researchers should consider incorporating a controlled and experimental group comparison. This addition would offer a comparative baseline, allowing for a more comprehensive assessment of the effectiveness of experiential AR-Quest activities. Additionally, extending the duration of the study to a longer time frame is recommended for a more nuanced understanding of the sustained impact of the intervention.

Acknowledgements

This research was supported by King Mongkut's Institute of Technology Ladkrabang.

References

Bodkhe, U., Verma, A., Saraswat, D., Bhattacharya, P., & Tanwar, S. (2022). *Adoption of Blockchain for Data Privacy in 6G-Envisioned Augmented Reality: Opportunities and Challenges*, Singapore.

Cannon, H. M., & Feinstein, A. H. (2014). *Bloom beyond Bloom: Using the revised taxonomy to develop experiential learning strategies.* Paper presented at the Developments in Business Simulation and Experiential Learning: Proceedings of the Annual ABSEL conference.

Carmigniani, J., & Furht, B. (2011). Augmented Reality: An Overview. In B. Furht (Ed.), *Handbook of Augmented Reality* (pp. 3-46). New York, NY: Springer New York.

Choi, J. H., & Hwang, B. K. (2017, 13-16 Nov. 2017). *The STEAM education proliferation activities on schools & its related sites using mobile STEAM trailers.* Paper presented at the 2017 7th World Engineering Education Forum (WEEF).

Eang, N. (2019). *The development of an ar-quest instructional design model based on situated learning to enhance the ability to remember Khmer vocabulary of Thai undergraduate students.* (Master's Degree). Chulalongkorn University, Chulalongkorn University.

Eang, N., & Na-Songkhla, J. (2020). The framework of an AR-quest instructional design model based on situated learning to enhance Thai undergraduate students' Khmer vocabulary ability. *LEARN Journal: Language Education and Acquisition Research Network, 13*(1), 161-177.

Gopalan, V., Bakar, J. A. A., & Zulkifli, A. N. (2017). A brief review of augmented reality science learning. *AIP Conference Proceedings, 1891*(1). doi:10.1063/1.5005377

Hawtrey, K. (2007). Using Experiential Learning Techniques. *The Journal of Economic Education, 38*(2), 143-152. doi:10.3200/JECE.38.2.143-152

Haynes, C. (2007). Experiential learning: Learning by doing. *Retrieved February, 18*, 2014.

Hill, V., & Knutzen, K. B. (2017). Virtual world global collaboration: an educational quest. *Information and Learning Science, 118*(9/10), 547-565.

Houle, C. O. (1961). The Doctorate in Adult Education. *Adult Education, 11*(3), 131-134. doi:10.1177/074171366101100302

Huang, T.-C. (2019). Seeing creativity in an augmented experiential learning environment. *Universal Access in the Information Society, 18*(2), 301-313. doi:10.1007/s10209-017-0592-2

Itin, C. M. (1999). Reasserting the Philosophy of Experiential Education as a Vehicle for Change in the 21st Century. *Journal of Experiential Education, 22*(2), 91-98. doi:10.1177/105382599902200206

Kaur, S., & Kauts, A. (2018). Impact of WebQuest on student engagement. *Indian Journal Of Public Health, 9*(12), 1665-1669.

Konak, A., Clark, T. K., & Nasereddin, M. (2014). Using Kolb's Experiential Learning Cycle to improve student learning in virtual computer laboratories. *Computers & Education, 72*, 11-22.

Lee, J., Lee, H.-K., Jeong, D., Lee, J., Kim, T., & Lee, J. (2021). Developing Museum Education Content: AR Blended Learning. *International Journal of Art & Design Education, 40*(3), 473-491. doi:https://doi.org/10.1111/jade.12352

Masood, T., & Egger, J. (2019). Augmented reality in support of Industry 4.0—Implementation challenges and success factors. *Robotics and Computer-Integrated Manufacturing, 58*, 181-195. doi:https://doi.org/10.1016/j.rcim.2019.02.003

McDougall, K. (2014). *Experiential Learning for the History Classroom: Engaging Learners on Different Levels and in Different Ways to Encourage a Lifelong Love of Learning.* (Master). University of Toronto, University of Toronto. Retrieved from http://hdl.handle.net/1807/67044

Moorhouse, N., tom Dieck, M. C., & Jung, T. (2019). An experiential view to children learning in museums with augmented reality. *Museum Management and Curatorship, 34*(4), 402-418.

Murphy, E. J. (2007). Prior Learning Assessment: A review of Bloom's taxonomy and Kolb's theory of experiential learning: Practical uses for prior learning assessment. *The Journal of Continuing Higher Education, 55*(3), 64-66.

Pugh, K. J., & Girod, M. (2007). Science, art, and experience: Constructing a science pedagogy from Dewey's aesthetics. *Journal of Science Teacher Education, 18*, 9-27.

Rabbi, I., & Ullah, S. (2013). A survey on augmented reality challenges and tracking. *Acta graphica: znanstveni časopis za tiskarstvo i grafičke komunikacije, 24*(1-2), 29-46.

Rogers, S., Jeffery, A., Pringle, J., Law, A., Nobajas, A., Szkornik, K., . . . Hobson, L. (2023). Experiential and authentic learning in a Living Lab: the role of a campus-based Living Lab as a teaching and learning environment. *Journal of Learning Development in Higher Education*(28).

Supratman, L. P., & Wahyudin, A. (2021). Communicating The Collaborative Lecturing Style to Millenial Learner in The Classroom. *Nyimak: Journal of Communication, 5*(2), 189-202.

Warda, A., & Mohammed, M. H. (2016). Can Collaborative Learning Maximize the Effectiveness of Web Quest Used in Learning Educational Psychology at Al Majmaa University? *Journal of Research in Curriculum Instruction and Educational Technology, 2*(4), 117-144.

Yardley, S., Teunissen, P. W., & Dornan, T. (2012). Experiential learning: Transforming theory into practice. *Medical Teacher, 34*(2), 161-164. doi:10.3109/0142159X.2012.643264

Contact email: eang.norphealey@gmail.com