Interactive Augmented Reality Technology via Blended Instruction Lesson on Cloud

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Abstract

The study aims to study the processes of the interactive augmented reality technology via blended instruction lesson on cloud, to design the interactive augmented reality technology via blended instruction lesson on cloud, to develop the interactive augmented reality technology via blended instruction lesson on cloud and to study the results of the development of interactive augmented reality technology via blended instruction lesson on cloud. The study's sample was selected using purposive sampling, i.e., 5 people from various higher education institutions and 30 people from undergraduate students in the first year of social sciences division in Pakse Teacher Training College, Lao PDR. The results showed the following: 1) the results of the quality assessment of developed blended instruction lesson on cloud had an overall very high level (mean = 4.51, SD = 0.57); 2) the results of the developed blended instruction lesson on cloud summarised that the results of the post-test achieved a score higher than the pre-test, which is statistically significant at 0.01; 3) the results of the assessment of the digital literacy of students after studying had a good level (mean = 40.73, SD = 2.18); and 4) the results of the student satisfaction to study with the developed blended instruction lesson on cloud were found to have a high level of satisfaction (mean = 4.31, SD = 0.55).

Keywords: interactive augmented reality, blended instruction, cloud learning, digital literacy

1. Introduction

Advances in technology have changed the human way of life in almost every aspect, such as industry, agriculture, medicine, management, art, science and education. We cannot separate every human action from technology (Anisimova, 2020). With regard to teaching and learning, educational institutions have encouraged the use of more technology in teaching and learning, especially during the coronavirus or COVID-19 pandemic. As a result, teaching and learning need to be adapted to online learning. Blended learning is another method of teaching and learning that combines traditional and online learning (Hasanah & Malik, 2020).

Cloud technology or cloud learning is an online learning tool with an online learning management system for content management, learner management and online test. Learners can access the content of a lesson from anywhere (Banjongarn, Tuntiwongwanich & Tungkunanun, 2019). This can support improving the learning process to be more efficient. It allows learners to learn by themselves (Stahl, 2021). Augmented reality is another technology that plays a role in teaching and learning by visualising images through a virtual media development programme that can display images in 3D media by working through mobile devices in visual, audio and video formats where learners can interact with learning materials (Imamoglu, 2020). Information technology has infiltrated all aspects of human life, including education. Therefore, digital literacy knowledge is as critical as learning and life skills. It is also capable of using software and digital technology, and cognition and building data from digital tools (Pratolo & Solikhati, 2021) that everyone must learn, especially the young generation learners who have contributed significantly to the economic and social development of the country.

From the above concepts and reasons, researchers can develop interactive augmented reality technology via blended instruction lesson on cloud. So learners can learn by themselves through learning methods that apply cloud technology to support online learning and make it interesting to learn with interactive augmented reality technology and to enhance the digital literacy of learners. Creating digital literacy skills is one of the critical

skills for 21st-century learners that contributes to the digital learning society presently.

2. Literature Review

With the development of interactive augmented reality technology via blended instruction lesson on cloud, the researcher has explored the relevant documents, texts and research as a guide to develop and apply to complete the study as descried below.

2.1 Blended Learning

Blended learning is an innovative concept that embraces the advantages of both traditional teaching in the classroom and ICT supported learning including both offline learning and online learning. Carman (2002) said that blended learning combines online and traditional classroom learning. By linking with continuously evolving technologies, it directly affects blended learning (Fuller, 2021). Martín-Martínez, Sainz & Rodríguez-Legendre (2020) found that blended learning is suitable for use in university, balancing education with personal circumstances and family and work responsibilities. This blended approach has essential benefits of distance education, in addition to the advantages of face-to-face learning with teachers and classmates. The application of blended learning methods is an additional element in learning, which promotes the development of knowledge and skills both individually and in collaboration. The highlight of the blended learning model is a learner-centre learning system that requires learners to be actively involved in each group or personal learning activity by making learners stay confident, motivating them to present ideas and respecting and appreciating the opinions of their classmates. In addition, online communication can facilitate them to share knowledge (Hasanah & Malik, 2020). Students report that the blended learning approach is better than traditional learning in a classroom. In addition, learning resources are beneficial and valuable. Furthermore, a blended learning approach improves the understanding of course concepts and familiarity with new technologies (Jackman, 2018).

Lalima & Dangwal (2017) said that blended learning is the concept that includes framing teaching–learning process that incorporates both face-to-face teaching and teaching supported by ICT. Blended learning incorporates direct instruction, indirect instruction, collaborative teaching and individualised computer-assisted learning. As the figure shows, it includes (1) face-to-face teaching, (2) student interaction with course content, (3) peer group interaction, (4) group discussion and exchange of ideas, (5) accessing e-library, (6) virtual classroom, (7) online assessment, (8) e-tuitions, (9) accessing and maintaining educational blog, (10) webinars, (11) viewing expert lectures in YouTube, (12) online learning through videos and audios and (13) virtual laboratory.

2.2 Cloud Learning

Cloud learning is a real-time online processing technology that uses the internet for teaching and learning. Then, learners can learn by themselves, from anywhere, at any time. There are tools to enable teachers to manage classrooms through the cloud system provided (Boonprasom & Sintanakul, 2019; Pence, 2020). However, Okai-Ugbaje et al. (2020) found that cloud computing has many benefits for teaching and learning, including flexibility and ease of use, and significantly reduces the time and needed resources. It allows learners easy access to content from anywhere, at any time. Boonprasom & Sintanakul (2019) summarised the composition of cloud learning, consisting of six elements: 1) learning content management tools, 2) collaboration tools, 3) communication tools, 4) productivity tools, 5) presentation tools and 6) evaluation tools. Cloud computing uses external data centres for processing, so it is an economic advantage because universities do not pay for and maintain expensive hardware on-site anymore. It can be used through cloud providers such as Amazon, Google or Microsoft, meaning it no longer needs their computers (Pence, 2020).

2.3 Augmented Reality Technology

Augmented reality technology is a technology that combines reality and the virtual world through devices and software enabling the presentation of 3D images, graphics and text, which are displayed to overlap the real world through devices such as computers, smartphones, tablets, wearables etc. (Bojukrapan, 2018). The study of Hanid, Said & Yahala (2020) found that learning using augmented reality, and interactive games can effectively enhance teaching and learning.

Augmented reality has a working principle that can be categorised into two types of image analysis: using marker as the main work (marker-based AR) and using different characteristics in the image for analysis (marker-less-based AR) (Kaur, Mantri & Horan, 2020; Wannapiroon et al., 2021). The elements of virtual reality technology include a marker (also known as a markup), video camera, webcam, cell phone camera or other sensors. Display components include display devices and processor software for 3D objects. The application of augmented reality technology in learning and teaching should allow students to collaborate to assist them in understanding lessons and their interest in learning. Augmented reality technology can be applied to other

technologies in education and provide information to students anywhere with a virtual reality experience. This then leads to collaboration between students and a deep understanding of what they are learning (Wittayakhom & Piriyasurawong, 2020).

2.4 Interactive Learning

Interactive learning is an approach to teaching and learning that focuses on various ways in which learning activities can 'interact' with learners. One of the key components of interactive learning is 'information' and the design of teaching materials to attract learners, creating a greater desire to learn. Students can prepare for class by interacting with provided resources to reduce lecture time and allow more engagement in class. Such engagement helps create a comfortable level of interaction between learners and teachers. This is an area that motivates learners, especially children and young people, who are close to the new generation of electronic devices (Wannapiroon et al., 2021). Interactive learning is advantageous as it helps establish a friendly atmosphere among the participants and have them connect with each other, helps boost learner self-reliance and self-assurance, and has participants making active and continual use of the knowledge and experience gained earlier. Thus, the effectiveness of interactive technology depends on how well it factors in the personal characteristics of each subject of the learning process and the prospects for their development (Abykanova et al., 2016).

2.5 Digital Literacy

UNESCO (2018) has defined the digital literacy framework as the ability to access, understand, use and create information safely and appropriately through digital technology. To work effectively requires computer knowledge, ICT knowledge, information knowledge and media literacy. Hamutoglu et al. (2020) said that digital literacy is a significant problem for education participants, including students, teachers and policymakers, whose digital literacy skills are needed in the 21st century with learning and life skills. The presentation of digital knowledge sources is the ability to obtain data from various forms on a computer, use software and digital technology, and cognition and construct data by digital tools.

According to the aforementioned theories and principles, digital literacy skills are associated with understanding and application of digital technology that encourage learners to develop lifelong learning. The said skills also create a learning society based on the application of information technology. Digital literacy or digital learning refers to the ability to create a variety of content with the use of different digital tools that are related to one another. The ability for digital literacy consists of three important aspects: using, understanding and creating. Digital literacy also covers the diversity of skills that are interrelated to one another; thereby, the said skills are included in media literacy, technology literacy, information literacy, visual literacy, communication literacy and social literacy.

3. Research Objectives and Hypotheses

In this study, the researcher set the following objectives:

O1: Study the processes of the interactive augmented reality technology via blended instruction lesson on cloud.

O2: Design the interactive augmented reality technology via blended instruction lesson on cloud.

O3: Develop the interactive augmented reality technology via blended instruction lesson on cloud.

O4: Study the results of the development of interactive augmented reality technology via blended instruction lesson on cloud.

The research hypothesis for the study of the development of interactive augmented reality technology via blended instruction lesson on cloud is as follows:

H1: The quality of the interactive augmented reality technology via blended instruction lesson on cloud is at a high level.

H2: Students' learning achievement post-study using developed blended instruction lesson is higher than pre-study, significantly at 0.01.

H3: The digital literacy of students who learned with developed blended instruction lesson post-study is at a good level.

H4: The satisfaction assessment results of students who learned with interactive augmented reality technology via blended instruction lesson on cloud are at a high level.

4. Research Methodology

The development of interactive augmented reality technology via blended instruction lesson on cloud is based on blended learning concepts combined with the adoption of self-directed learning processes as a guideline to provide interactive augmented reality technology via blended instruction lesson on cloud.

4.1 Participants

The sample of the study is divided into two groups, including (1) experienced professionals in teaching and learning design issues, content issues, information and communication technology for education issues from various higher education institutions, consisting totally of 5 people, and (2) undergraduate students in the first year of social sciences division in Pakse Teacher Training College, Lao PDR, derived from purposive sampling, consisting totally of 30 people.

4.2 Data Collection and Analysis

With the development of interactive augmented reality technology via blended instruction lesson on cloud, the researchers developed and used data collection tools as follows: (1) the blended instruction lesson on cloud via interactive augmented reality technology; (2) an assessment form for the quality of interactive augmented reality technology via blended instruction lesson on cloud; (3) achievement tests for pre-study and post-study for interactive augmented reality technology via blended instruction lesson on cloud; (4) a post-test for learner's digital literacy evaluation of interactive augmented reality technology via blended instruction lesson on cloud; (5) an assessment form for satisfaction to interactive augmented reality technology via blended instruction lesson on cloud. Statistics used for data analysis include means, standard deviations and t-test.

4.3 Methodology

The development of interactive augmented reality technology via blended instruction lesson on cloud is divided into four stages, as shown in Figure 1.

Stage 1: Study the processes of interactive augmented reality technology via blended instruction lesson on cloud from related articles and research, including blended learning, cloud learning, augmented reality technology, interactive media, digital literacy and learning achievement.

Stage 2: Design the interactive augmented reality technology via blended instruction lesson on cloud. The researchers designed learning content based on blended learning combined with self-directed learning processes to guide blended learning on cloud.

Stage 3: Develop the interactive augmented reality technology via blended instruction lesson on cloud. At this stage, the researchers develop blended instruction lesson on cloud via interactive augmented reality technology as learning activities to enable learners to interact with lessons in the creation by self-learning.

Stage 4: Study the results of using interactive augmented reality technology via blended instruction lesson on cloud. It is a study of the effects of three issues, such as learning achievement, digital literacy and satisfaction.
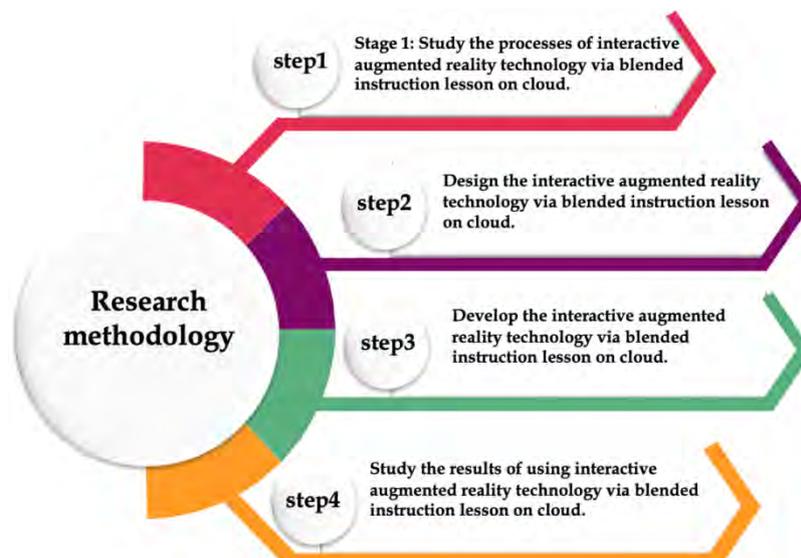

Figure 1. Research methodology

5. Results and Discussion

The results of the study of interactive augmented reality technology via blended instruction lesson on cloud are summarised in two sections.

Section 1: Results of the Development of Interactive Augmented Reality Technology via Blended Instruction Lesson on Cloud.

5.1 Conceptual Framework for the Development of Interactive Augmented Reality Technology via Blended Instruction Lesson on Cloud

The synthesis of the conceptual framework for developing interactive augmented reality technology via blended instruction lesson on cloud. Studies from theories, relevant articles and research include blended learning (Carman, 2002; Fuller, 2021), cloud learning (Boonprasom & Sintanakul, 2019; Okai-Ugbaje et al., 2020; Pence, 2020), augmented reality technology (Bojukrapan, 2018; Ditcharoen & Ratthirom, 2016), interactive learning (Abykanova et al., 2016; Wannapiroon et al., 2021), digital literacy (UNESCO, 2018; HAMUTOGLU et al., 2020), achievement and satisfaction. Then, we analyse and synthesise the relevant theories to construct the conceptual framework for developing interactive augmented reality technology via blended instruction lesson on cloud.

5.2 Interactive Augmented Reality Technology via Blended Instruction Lesson on Cloud

The interactive augmented reality technology via blended instruction lesson on cloud is developed based on blended learning concepts combined with the adoption of self-directed learning processes as a guideline to provide blended instruction lesson on cloud to enhance digital literacy and to encourage learners to reach learning through digital technology as needed. It can interact with each one through developed social networks, as shown in Figure 2.
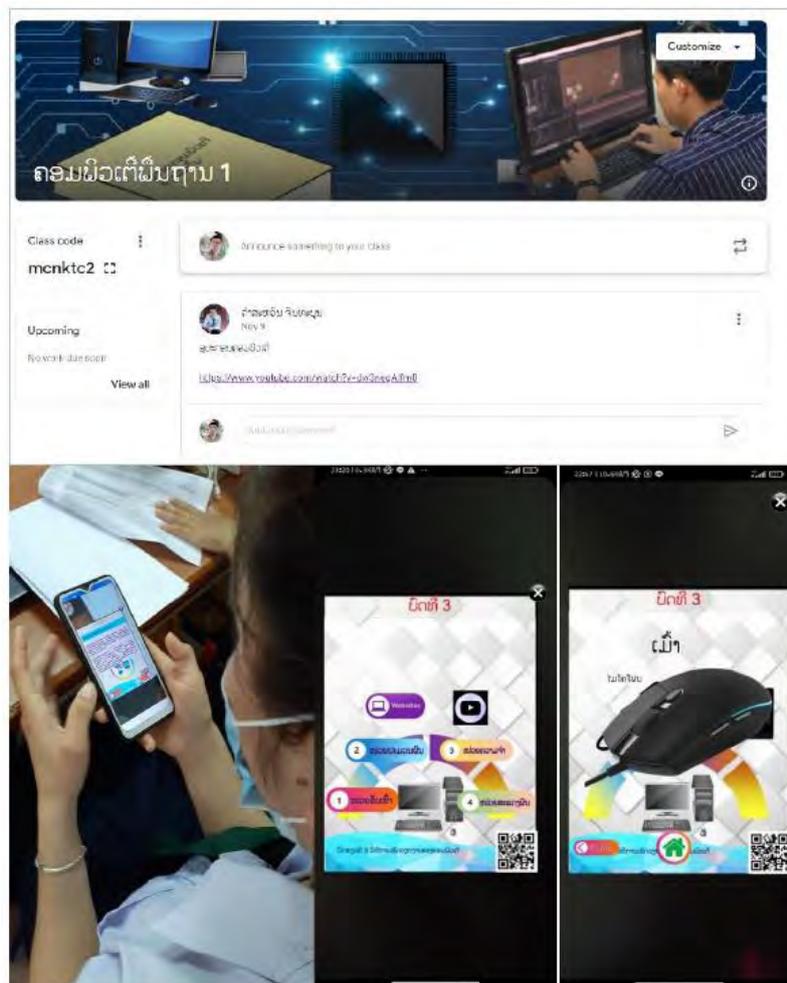

Figure 2. The interactive augmented reality technology via blended instruction lesson on cloud: case study of Pakse Teacher Training College, Lao PDR

Section 2: Results of using Interactive Augmented Reality Technology via Blended Instruction Lesson.

Study the results of using interactive augmented reality technology via blended instruction lesson on cloud. The researchers used data analysis and interpretation criteria of Kanasutra (1995), as shown in Table 1.

Table 1. Range of average scores and interpretation of results

Range of average score	Interpretation of appropriateness
4.50 – 5.00	Very high
3.50 – 4.49	High
2.50 – 3.49	Moderate
1.50 – 2.49	Low
0.00 – 1.49	Very low

The results of using interactive augmented reality technology via blended instruction lesson are summarised as follows: (1) an assessment results of quality of using interactive augmented reality technology via blended instruction lesson; (2) learning achievement results from comparing students' pre-test and post-test scores based on the interactive augmented reality technology via blended instruction lesson; (3) results of the assessment of students' digital literacy after studying based on the interactive augmented reality technology via blended instruction lesson; and (4) results of the assessment of student satisfaction to learning based on the interactive augmented reality technology via blended instruction lesson. The results of the study are summarised below.

5.3 Assessment Results of the Quality of using Interactive Augmented Reality Technology via Blended Instruction Lesson

Table 2. Assessment results of quality of using interactive augmented reality technology via blended instruction lesson

Assessment issues	Assessment results		
	Mean	SD	Interpretation
1. Content issue	4.53	0.60	Very high
2. Design issue	4.51	0.58	Very high
3. Information technology in promoting digital literacy issue	4.58	0.48	Very high
4. Blended instruction lesson on cloud via interactive augmented reality technology issue	4.40	0.62	High
Overall average	4.51	0.57	Very high

From Table 2, it can be found that the blended instruction lesson on cloud, by experts who are experienced in learning design, content and information and communication technology for education from various higher education institutions, has an overall quality that is very high (mean = 4.51, SD = 0.57). The findings show that developed interactive augmented reality technology via blended instruction lesson can be used as a guideline to enhance learning and encourage students to learn in various ways and at any time by use of information technology. It is practical and enables learning and problem-solving freely, which is in line with hypothesis 1.

5.4 Results of Learning Achievement from Comparing Students' Pre-test and Post-test Scores Based on the Interactive Augmented Reality Technology via Blended Instruction Lesson

The results of the study of developed interactive augmented reality technology via blended instruction lesson show a comparison of students' pre-test and post-test scores based on the interactive augmented reality technology via blended instruction lesson, are shown in Table 3.

Table 3. A comparison of students' pre-test and post-test scores based on the interactive augmented reality technology via blended instruction lesson

Issues	Total score	Mean	SD	t-test	Sig.
Pre-test	49	19.27	2.46	23.86	0.00[**]
Post-test	49	41.10	3.85		

[**]p< 0.01

Table 3, a comparison of students' pre-test and post-test scores, shows a sample group studying by interactive augmented reality technology via blended instruction lesson using one-group pre-test–post-test design. The

learning achievement of post-test score is higher than pre-test score class. When considering the average score of learning achievement, students had an average learning achievement of the post-test score (mean = 41.10, SD = 3.85), which is higher than the average learning achievement of the pre-test score (mean = 19.27, SD = 2.46). This shows that studying interactive augmented reality technology via blended instruction lesson can achieve higher students' learning achievement, which is statistically significant at 0.01. This is consistent with hypothesis 2. In addition, the above findings were consistent with the study of Phunaploy, Chatwattana & Piriyasurawong (2021), which found that developing online learning encourages learners to challenge them by creating learning processes for curious learners. Students can seek their knowledge from all kinds of learning materials, including print and digital media, which can access learning resources anytime and from anywhere, at the same time, emphasising that they have the skills to search and use information technology to assist students in succeeding in their studies, as well as encouraging students to participate in learning and support improvement of learning achievement.

5.5 Results of the Assessment of Students' Digital Literacy after Studying based on the Interactive Augmented Reality Technology via Blended Instruction Lesson

The results of the assessment of students' digital literacy after studying based on interactive augmented reality technology via blended instruction lesson, using the authentic assessment form by rubric score of Dangprasert (2021), are shown in Table 4.

Table 4. Range of average score and level of digital literacy interpretation

Average score range	Interpretation
46.67 - 60.00	Excellent
33.34 - 46.67	Good
20.01 - 33.33	Fair
0.00 - 20.00	Poor

The results of the assessment of students' digital literacy after studying based on interactive augmented reality technology via blended instruction lesson are shown in Table 5.

Table 5. Results of the assessment of students' digital literacy after studying based on interactive augmented reality technology via blended instruction lesson

N	Total score	Mean	SD	Interpretation
30	60	40.73	2.18	Good

From Table 5, we can see the results of the assessment of students' digital literacy after studying based on interactive augmented reality technology via blended instruction lesson, based on authentic assessment by instructors. When considering the average digital literacy score, the students had an average digital literacy score after studying at a good level (mean = 40.73, SD = 2.18). This corresponds with hypothesis 3 and is consistent with the study of Chatwattana (2021), who said that integrated new technology and learning models can achieve new ideas and innovations to support learning for modern learners and can respond directly to learners' experience: creating a society of learning in digital universities, and learners can learn anytime, anywhere in a learning model that focuses on and learners to experience self-learning; and encouraging students to be skilled and capable of planning their studies and evaluating their learning. They plan their studies and evaluate through social networks to enhance students' digital literacy.

5.6 Results of the Assessment of Student Satisfaction to Learning based on the Interactive Augmented Reality Technology via Blended Instruction Lesson

The results of the assessment of student satisfaction to studying based on the interactive augmented reality technology via blended instruction lesson, under three consideration issues, such as content, instruction design and blended instruction lesson on cloud via interactive augmented reality technology, are shown in Table 6.

Table 6. Results of the assessment of student satisfaction to learning based on the interactive augmented reality technology via blended instruction lesson (three consideration issues)

Assessment issues	Assessment results		
	Mean	SD	Interpretation
1. Content issue	4.35	0.53	High
2. Instruction design issue	4.38	0.52	High
3. Blended instruction lesson on cloud via interactive augmented reality technology issue	4.20	0.06	High
Overall average	4.31	0.55	High

Table 6 shows that the assessment of student satisfaction to learning based on the interactive augmented reality technology via blended instruction lesson overall under three consideration issues had a high level (mean = 4.31, SD = 0.55). When considering each aspect, overall satisfaction to three elements (content, instruction design and blended instruction lesson on cloud via interactive augmented reality technology) had a high level. This is consistent with hypothesis 4. In addition, the above findings are consistent with the study of Wannapiroon et al. (2021), who found that augmented reality technology and imagineering process are flexible in teaching and learning. They can be adapted to various teaching methods and contexts that use augmented reality technology for learning in the SMART classroom as a learning source database and can be used to review knowledge as a teaching media for students to create work pieces.

6. Conclusion

The interactive augmented reality technology via blended instruction lesson is a tool to support self-learning by the ideas of integration of information technology and augmented reality technology to support modern learners. It can respond directly to their learning experiences with blended instruction lesson on cloud via interactive augmented reality technology that encourages learners to study at anytime, anywhere and can challenge learning and digital literacy by using existing technologies to maximise profits and create a learning society.

The development of interactive augmented reality technology via blended instruction lesson is divided into four stages, i.e., study the processes of interactive augmented reality technology via blended instruction lesson, design the interactive augmented reality technology via blended instruction lesson, develop the interactive augmented reality technology via blended instruction lesson and study the results of using interactive augmented reality technology via blended instruction lesson. The results of using interactive augmented reality technology via blended instruction lesson found that (1) the results of the quality assessment of developed blended instruction lesson on cloud overall had a very high level, which is in line with hypothesis 1; (2) the post-test has an achievement score higher than pre-test, which is statistically significant at 0.01, which is consistent with hypothesis 2; (3) the result of the assessment of the digital literacy score of students after studying had a good level, which is in line with hypothesis 3; and (4) the results of the student satisfaction to study with the developed blended instruction lesson on cloud had a high level, which is consistent with hypothesis 4.

This research can be applied as a guideline to design and develop blended instruction lesson with modern technology that can promote online education, higher education, open education and distance education. In addition, this can lead to a learning society in which the concepts, elements and processes of interactive learning that are used as guidelines for designing teaching processes and teaching activities. The limitations of research were derived from a purposive sampling and small sample size, resulting in variability and inaccuracies in findings, if applied to larger samples.

References

Abykanova, B., Nugumanova, S., Yelezhanova, S., Kabylkhamit, Z., & Sabirova, Z. (2016). The use of interactive learning technology in institutions of higher learning. *International Journal of Environmental & Science Education, 11*(18), 12528-12539.

Anisimova, E. S. (2020). Digital literacy of future preschool teachers. *Journal of Social Studies Education Research, 11*(1), 230-253.

Banjongarn, P., Tuntiwongwanich, S., & Tungkunanun, P. (2019). Learning management system of socratic project-based learning via collaborative cloud-learning on technology subject (Computer science), *Journal of industrial education, 10*(2), 218-225.

Bojukrapan, S. (2018). Development of multimedia's english vocabulary with augmented reality technology.

Journal of Technology Management Rajabhat Maha Sarakham University, 3(2), 58-64.

Boonprasom, C., & Sintanakul, K. (2019). The synthesis of model of collaborative to enhance critical thinking of undergraduate student. *Journal of Industrial Education, 18*(3), 165-173.

Carman, J. M. (2002). *Blended learning design: Five key ingredients*. Retrieved from http://blended2010.pbworks.com/f/Carman.pdf

Chatwattana, P. (2021). A MOOC system with self-directed learning in a digital university. *Global Journal of Engineering Education, 23*(2), 134-142.

Dangprasert, S. (2021). Effects on using tutoring application in integration with self-directed learning to improve statistical analysis skills. *TEM Journal, 10*(1), 63-68. https://doi.org/10.18421/TEM101-08

Ditcharoen, N., & Ratthirom, A. (2016). Development of 3D zoo book using augmented reality technology on android. *Journal of Research Unit on Science, Technology and Environment for Learning, 7*(1), 77-87.

Fuller, L. (2021). Negotiating a new blend in blended learning: Research roots. *Inquiry: The Journal of the Virginia Community Colleges, 24*(1). Retrieved from https://commons.vccs.edu/inquiry/vol24/iss1/6

HAMUTOGLU, B. N., GEMIKONAKLI, O., RAFFAELE, D. C., & GEZGIN, M. D. (2020). Comparative cross-cultural study in digital literacy. *Eurasian Journal of Educational Research, 88*, 121-148. https://doi.org/10.14689/ejer.2020.88.6

Hanid, M. F. A., Said, M. N., & Yahaya, N. (2020). Learning strategies using augmented reality technology in education: Meta-analysis. *Universal Journal of Educational Research, 8*(5A), 51-56. https://doi.org/10.13189/ujer.2020.081908

Hasanah, H., & Malik, M. N. (2020). Blended learning in improving students' critical thinking and communication skills at university. *Cypriot Journal of Educational Sciences, 15*(5), 1295-1306. https://doi.org/10.18844/cjes.v15i5.5168

Imamoglu, M. (2020). Enhanced educational mobile augmented reality application for musculoskeletal system and warm-up exercises, *Asian Journal of Contemporary Education, 4*(2), 91-98. https://doi.org/10.18488/journal.137.2020.42.91.98

Jackman, W. M. (2018). Switching from traditional to blended learning at university level: Students' and lecturers' experiences. *International Journal of Learning, Teaching and Educational Research, 17*(5), 1-14. https://doi.org/10.26803/ijlter.17.5.1

Kanasutra, P. (1995). *Statistics for research in the behavioral Sciences*. Bangkok: Chulalongkorn University Press.

Kaur, D. P., Mantri, A., & Horan, B. (2020). Enhancing student motivation with use of augmented reality for interactive learning in engineering education. *Procedia Computer Science, 172*, 881-885. https://doi.org/10.1016/j.procs.2020.05.127

Lalima., & Dangwal, L. K. (2017). Blended learning: An innovative approach. *Universal Journal of Educational Research, 5*(1), 129-136. https://doi.org/10.13189/ujer.2017.050116

Martín-Martínez, L., Sainz, V., & Rodríguez-Legendre, F. (2020). Evaluation of a blended learning model for pre-service teachers. *Knowledge Management & E-Learning, 12*(2), 147-164. https://doi.org/10.34105/j.kmel.2020.12.008

Okai-Ugbaje, S., Ardzejewska, K., Imran, A., Yakubu, A., & Yakubu, M. (2020). Cloud-based m-learning: A pedagogical tool to manage infrastructural limitations and enhance learning. *International Journal of Education and Development using Information and Communication Technology, 16*(2), 48-67.

Pence, E. H. (2020). How should chemistry educators respond to the next generation of technology change?, *Education Sciences, 10*(2), 34. https://doi.org/10.3390/educsci10020034

Phunaploy, N., Chatwattana, P., & Piriyasurawong., P. (2021). The results of development the online instruction with design-Based thinking for construction a creative products. *TEM Journal, 10*(4), 1715-1720. https://doi.org/10.18421/TEM104-30

Pratolo, W. B., & Solikhati, A. H. (2021) Investigating teachers' attitude toward digital literacy in EFL classroom, *Journal of Education and Learning, 15*(1), 97-103. https://doi.org/10.11591/edulearn.v15i1.15747

Stahl, G. (2021). Redesigning mathematical curriculum for blended learning, *Education Sciences, 11*(4), 165. https://doi.org/10.3390/educsci11040165

UNESCO. (2018). *A global framework of reference on digital literacy skills for indicator 4.4.2*. Quebec: UNESCO Institute for Statistics.

Wannapiroon, P., Nilsook, P., Kaewrattanapat, N., Wannapiroon, N., & Supa, W. (2021). Augmented reality interactive learning model, using the imagineering process for the SMART classroom. *TEM Journal, 10*(3), 1404-1417. https://doi.org/10.18421/TEM103-51

Wittayakhom, N., & Piriyasurawong, P. (2020). Learning management STEAM model on massive open online courses using augmented reality to enhance creativity and innovation. *Higher Education Studies, 10*(4), 44-53. https://doi.org/10.5539/hes.v10n4p44

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