Development of Supplementary Media on Electrical Circuits using AR Technology via Mobile Learning

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Abstract. *The purposes of this research are to develop supplementary media on electrical circuits using the AR technology via mobile learning and to evaluate the performance of the proposed media via mobile phones by comparing the learning proficiency results of electrical engineering students before and after used.*

In this research, there were 35 students who studied in electrical engineering and currently took the course on "electrical circuit" at Pitchayabundit College, Udon Thani, Thailand, for a semester (about 4 months). The proposed media was used for the course where the students were allowed to use mobile phones in the class all the time. The proficiency tests in terms of effectiveness and learning achievement were analyzed statistically. The experimental test results showed that effectiveness of the proposed supplementary media on electrical circuit course with AR technology was better with the rate of 80.07/82.28 (E_1/E_2). The learning achievement was evaluated via the pre-test and post- test, which revealed higher score by 9.49% when using the proposed media for the class.

Received by	22 June 2019
Revised by	25 June 2019
Accepted by	28 June 2019

Keywords:

Mobile Learning, Supplementary media, Electric circuit, AR technology

1. Introduction

Mobile devices, smart phones, Personal Digital Assistants (PDAs) and laptop computers have become attractive learning devices for modern education. Besides being parts for communication among the users, students could also utilize these devices for their daily planning, studying arrangement, accessing teaching materials and applications, multimedia entertainment through the social media activities and platforms. These would lead the study the more convenient and flexible. As a result, the conventional teaching class with full oral lectures or white board drawing would become less in attention for students [1], i.e., classroom lecture would lead students to remember only just 5%, self-independent reading up to 10%, listening and watching about 20% and seeing examples and practicum with about 30%. Therefore, new types of teaching devices become increase in number, for example, the top world university such as Harvard University, USA, has released a variety of modern learning activities.

Alternatively, supplementary media would become more attractive for the learning; where information can be delivered from other sources rather than old-fashion textbook teaching classes or individual reading. These types of media are known as digital learning-teaching, video documentation, e-learning, etc. [2].

Augmented Reality (AR) technology is the integration of digital information with the user's environment in real time. Unlike the Virtual Reality (VR) which creates totally an artificial environment, the AR uses the existing environment and overlays new information on top of it. In addition, portable electronic devices could be simply applied for the AR for the teaching as well. Teachers need to create teaching materials for the introduction of portable electronics applications. This could help students to have eagerness to the acquired knowledge, to be inquisitive, to learn new activities, to create new experience, to engage in the learning. In summary, learning with AR technology would provide the advantages as follows [3]:

1) Reduce restrictions on the boundary issues between the real and virtual environments

2) Able to leverage the world of reality

3) Able to study in the same classroom and distance

4) Able to identity students with more tangible

5) Able to change the translation of the given information and corresponding responses between the real world to the virtual world.

In this research, the development of supplementary media on electrical circuits with the AR technology via mobile phone learning is proposed. The students who had studied in electrical engineering at Pitchayabundit College, Udon Thani, Thailand, were employed to test the proposed media while studied with the electrical circuit course. The focusing points for this research are the effectiveness and learning achievement of the students when using the proposed media in the class.

2. Research Methodology

In order to develop the supplementary media using AR technology via mobile learning, the following information and steps had been completed:

1. Studies and data collection
2. Development of the supplementary media on electrical circuits with AR technology
3. Research populations and samples
4. Experimental tools
5. Data analysis

2.1 Studies and Data Collection

Document, Materials and relevant research works about enhancement of media learning with mobile devices, virtual reality and educational programs related to the preparation of teaching materials on mobile were studied and summarized [4]-[15].

In [5], the Learning Objects (LO) have been defined, which are any digital or non-digital entity that may be used for learning, education and training. LOs are the types of building blocks that consist of a virtually infinite number of techniques to construct collections. The Los therefore can be lessons, modules, courses or curricula [6]. These are main components for learning design construction, which are developed for learning management systems. Property of granularity allows LO reusability and aggregation them into larger units. During this project LO, in context of mobile learning, was divided in 5 categories: video, graphic, text, audio and QR code [15]. These kinds of mobile learning were then applied for this research.

2.2 Development of Supplementary Media on Electrical Circuits using AR Technology

Fig. 1 shows the conceptual framework for developing the supplementary media on electrical circuit course using AR technology. The core information and target knowledge is set as the teaching primary. The supplementary media is then created for each particular teaching primary topic with the AR technology and suitable mobile learning for the design. The developed media was then used by students who attended the electrical circuit class and the output results in terms of effectiveness and learning achievement were finally evaluated, by mean of the achievement. Fig. 2 presents the overview idea of the supplementary media structure. each teaching module consists of the pretest, course introduction, primary teaching content (หน่วยที่), exercise (แบบฝึกหัด) and post-test.

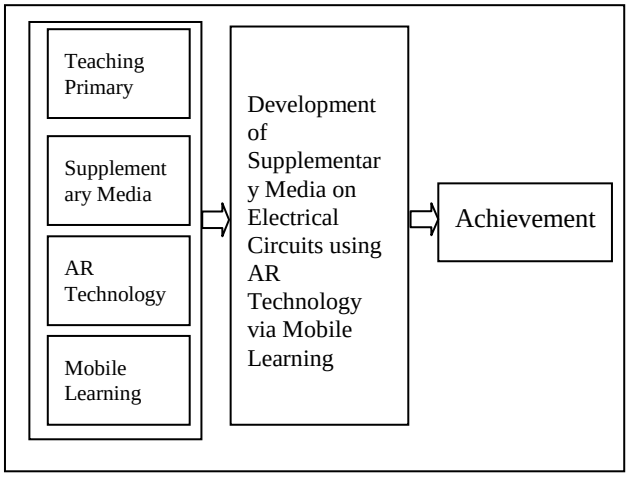


Fig. 1: Conceptual framework for supplementary media development.

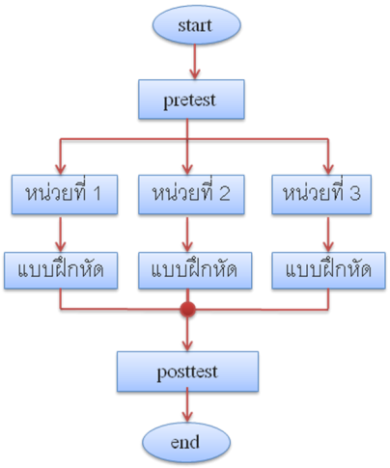


Fig. 2: The structure of the design supplementary media.

2.3 Populations and Samples

The population under this research was 583 students who had studied in Pitchayabundit College, Udon Thani, Thailand in the year 2019. Some students were randomly selected by 35 students to be ones who took the lecture class in electrical engineering and registered the course "electrical circuit".

2.4 Experimental Tools

There were 3 main experimental tools used in this research: the supplementary media for the electrical circuit course, the AR technology by Layar application [16] and the learning achievement test on electrical circuits with 30 multiple choices. The quality of the achievement test, index value and consistency between the aim of learning and achievement tests were examined by the experts. The quality of the achievement test [17].

$$IOC = \frac{\sum R}{N} \quad (1)$$

; where IOC is the consistency of the test

$\sum R$ is the total score comments of experts.

N is the number of experts.

The criteria for the consistency test in this research was classified as follows:

Consistent score = +1
Uncertain score = 0
Inconsistent score = -1

The content validity of the learning achievement test was defined and scored as follows:

Score: -1.00 to -0.60 = test purposes inconsistent
Score: -0.21 to 0.20 = uncertain
Score: 0.21 to 0.60 = test purposes consistent

The recognition of learning achievement test was derived by each question from the text, and then determined the average value, which gave the following results:

Score: -1.00 to -0.60 = very low quality
Score: -0.61 to -0.20 = low quality
Score: -0.21 to 0.20 = medium quality
Score: 0.21 to 0.60 = high quality
Score: 0.61 to 1.00 = very high quality

2.5 Data Analysis

The data collected from the tests were analyzed by using statistical evaluation: percentage, average-mean and standard deviation.

3. Research Results

The research results after surveyed and analyzed by the related factors found that:

(1) 96% of students had their own mobile phones for M-Learning.

(2) All mobile phones could fully support and access the wireless network such as Bluetooth, WiFi and GPRS.

(3) The minimum screen resolution was 480x800 pixels and most operating systems for the phones were Android.

(4) All mobile phone were compatible for installing the application and software used in this research.

Therefore, the research team utilized the above information to design and develop the proposed supplementary media for electrical circuit course using the AR technology that is a multimedia online is designed to enable access to mobile phone service. The screen resolution is 480x800 pixels operating system to Android. The first page contains the text greeting the students and menu consists of 3 courses introduced into lessons. And who taught the lessons of hot colors are orange, a color that stimulates learning. The students are eager to learn. The research findings were as follows: Table 1.

Number of students (n)	Test Score Results			
	During (40 points)		After (30 points)	
	Average	percent (E_1)	Average	percent (E_2)
35	32.02	80.07	24.69	82.28

Table 1 the effectiveness of the proposed supplementary media on electrical circuits with AR technology

From Table 1, it can be found that the effectiveness of the proposed supplementary media on the electrical circuits course using AR technology via mobile learning were 80.07 /82.28 (E_1/ E_2); calculated by using (2)-(3) [18].

$$E_1 = \frac{\sum x/n}{A} \times 100 \quad (2)$$

$$E_2 = \frac{\sum F/n}{B} \times 100 \quad (3)$$

; where E_1 is the percentage of average score during practicing
E_2 is the percentage of average score of post-test
$\sum x$ is the total score of during practicing.
$\sum F$ is the total score of post-test
n is the total number of students

Fig. 3 shows comparison results between the learning achievement of the students before (pre-test) and after (post-test) using the proposed supplementary media with AR technology. It can be seen that significant improvement almost 2.5 times could be achieved for all the students. In addition, the students who learned with the proposed supplementary media on the electrical circuits course with AR technology via mobile learning had the post-test learning achievement higher than the pre-test approximately by 9.49% in average. Students interact with teachers through the e-mails, facebook and mobile phones with AR.

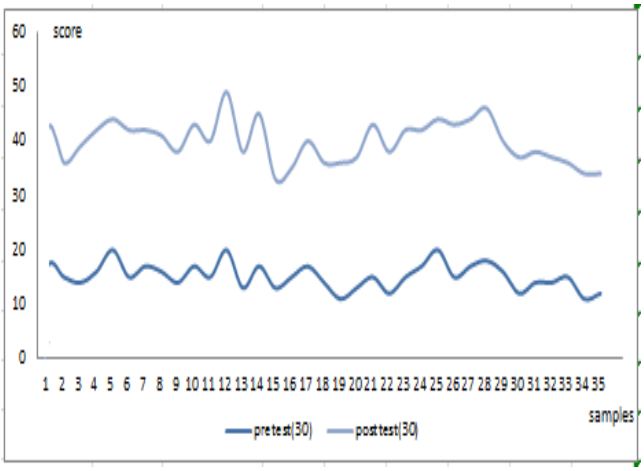
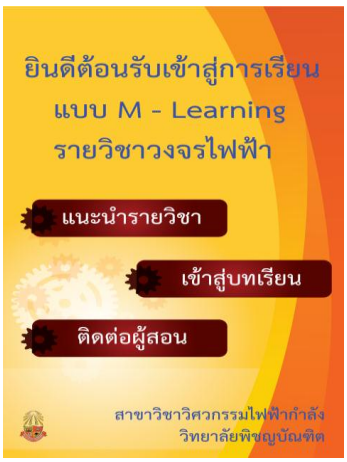


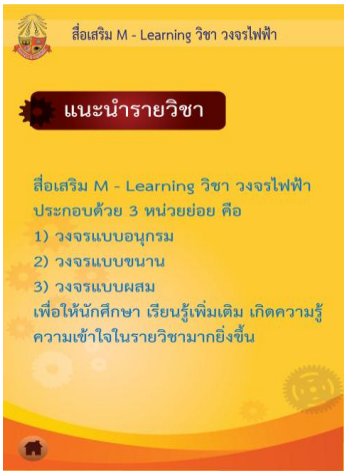
Fig. 3: Comparison of the learning achievement between pre-test and post-test

Fig. 4(a)-(c) present the designed supplementary media in this research. The students could access the first page of the media via their own mobile phones and could select the menu: course introduction (แนะนำรายวิชา), learning lessons (เข้าสู่บทเรียน) and contact teacher (ติดต่อผู้สอน), see Fig. 4(a). When getting into the tutorial, the students could select the topics that they were interested independently; see Fig. 4(b) while being about to always see the guideline for the course all the time required; see Fig.4(c).



(a)

(b)



(c)

Fig. 4 : Example of proposed supplementary media on the mobile phone screens: (a) main page, (b) learning lesson page and (c) guideline for the course

4. Discussions

The development of supplementary media for electrical circuits with AR technology via mobile learning achieved 80.07/82.28 pre-test and post-tests. The average score during the study was 32.02 points while the average score after the study was 24.69 points. The students had significant in improvement between the post-test learning achievements to be higher than the pre-test by 9.49% in average.

The supplementary media has designed and developed systematically. The designed learning paths were also more interactive form of knowledge for the students. Students could access and study the media anywhere and anytime unlimited. Students could communicate and interact with the teachers through several social media channels, i.e. e-mail, facebook and mobile phones with AR technology. The research team has designed and developed the supplementary media based on multimedia real time-online platform, which was designed to enable access to mobile phone service. Low screen resolution of 480x800 pixels could be used with Android operation system.

The first page of the media contained the text greeting the students and the menu consisted of 3 courses introduced into the lessons. Students who begun the lessons would start with orange colour to stimulate and alert the learners, as well as, eager to learn [19]. The test results showed that the achievement of higher learning or m-learning over the conventional teaching in regular classrooms. Test score results revealed that the knowledge of students about technology, multimedia learning system from m-learning higher technological knowledge using multimedia regular lessons, similar results to [20]. To stimulate interest and present the material with modern technology such as AR, social media, YouTube practice with a mobile and teaching through the electronic system also allowed the students to learn better.

In conclusion, the developed virtual reality enabled the audience to sense the images as if they were in the real place. The interactive 3D modeling, virtual environment, sound, teaching was gradually effective [21]. The AR technology helped to animate the contents in the classroom lessons and could attract students to engage the course all the times, as well as, motivating them to further self-study. Additionally, by including extra data and information, e.g. a short biography of successive persons, fun facts, historical data about sites or events and visual 3D models would provide students a wider understanding of topics. The AR technology also helped to render the objects that would be hard to imagine and difficult to understand to become the simple visualized with 3D models, thus making the learning to be easier. For example, Polytechnic Institute of Leiria in Portugal [22] integrated AR into Mathematics lessons and students reported it as a helpful, easy and interesting way of study. When doing homework, students would just only scan the certain elements of a book and receive text, audio or video tips from teachers; or else, they might find useful information about the course, a teacher or other students which could lead to better communication and learning [9].

5. Conclusions

The development of supplementary media using AR technology via mobile phone learning has been proposed in this paper. The media for electric circuit course had been investigated and examined with 35 students in electrical engineering at Pitchayabundit College, Udon Thani, Thailand for a semester in 2019. The pre-test and post-test evaluation was used. The research results showed that the

effective of the proposed supplementary media on electrical circuits with AR technology via mobile learning was as high as 80.07 / 82.28 (E_1/ E_2). The students who learned with supplementary media on electrical circuits with AR technology via mobile learning had significantly increased in the test score of the post-test learning achievement higher the pre-test by 9.49 %.

Acknowledgements

The authors would like to express gratitude to Pitchayabundit College, Udon Thani, Thailand, for research funding and supporting. Special thanks to all the experts who provided research tools and equipment, as well as, valued suggestions.

References

[1] Harvard Business Review. (2013). The Learning Pyramid. Retrieved October 20, 2013, From http:// stephenslighthouse.com/ 2010/ 02/ 26/ the-learning-pyramid/

[2] Monchai Teanthong . (2004). M-learning concept of e-Learning. Journal of Technology and Communications Year 1 (1).

[3] wiwat meesuwan. (2011). Augmented reality technology for learning. Journal of Education Naresuan University. 13(2), 119-127.

[4] Ophoff, J. (2013). Towards a Method for Mobile Learning Design. Issues in Informing Science and Information Technology, 10, 501–523.

[5] Timoko, T. (2014). Towards an Indigenous Model for Effective Mobile Learning. Communications in Computer and Information Science, 315–320.

[6] Paulins, N., Balina, S., & Arhipova, I. (2015). Learning Content Development Methodology for Mobile Devices. Procedia Computer Science, 43, 147–153.

[7] Hamdani, D. S. A. (2013). Mobile Learning: A Good Practice. Procedia - Social and Behavioral Sciences, 103, 665–674.

[8] Qiyan Han, & Feng Gao. (2012). Towards semantic learning object metadata: mapping standard metadata specifications to ontologies. Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012.

[9] Chikh, A. (2014). A general model of learning design objects. Journal of King Saud University - Computer and Information Sciences, 26(1), 29–40.

[10] Hyun-Jhin Lee. (2014). Inter-disciplinary Design Camp program development for k-12 students - Focused on learning of design & development for smart phone application -. Journal of Digital Design, 14(1), 477–486

[11] Cha, H. J., & Ahn, M. L. (2019). Design and development of a smart-tool prototype to promote differentiated instruction: a user-centered design approach. Interactive Learning Environments, 1–17.

[12] Prentice, M. (2014). Community College Service-Learning Programs: The Well-Traveled Path to Civic Engagement. Service-Learning at the American Community College, 185–197.

[13] Van, B. (1992). College Learning Assistance Programs: Ingredients for Success. Journal of College Reading and Learning, 24(2), 27–39.

[14] Gerlicher, A., & Jordine, T. (2018). Mobile Learning und Mobile Game-based Learning. Handbuch Mobile Learning, 161–176.

[15] De Witt, C. (2018). Mobile Learning – Smart Learning – Next Learning. Handbuch Mobile Learning, 995–1014.

[16] Sulaeman, Y. (2018). Application of Problem Based Learing Model in Analyzing Nationalism of Poetry "Di Bawah Layar" by D. Zawawi Imron. Alinea: Jurnal Bahasa, Sastra, Dan Pengajaran, 1(2), 72.

[17] Boonchom Srisaad.(1992). Introduction to research. 2nd Edition.Bangkok. publisher Suweriyasan. Srinakharinwirot University prasanmit

[18] Chaiyong Promwong.(2000).Technology and communications course instruction, educational technology unit at 1-4. Nonthaburi.Sukhothai thammathirat University.

[19] Thongchai Keawkiriya.(2003). E-Learning towards M-Learning in the Age of Social Communication Without Borders.

[20] Wilawan Phornphatcharaphong, Suttipong Hoxsuwan and Thapanee Seechaliao.(2018). The effect of technology-based instruction model on undergraduate students' english communication skills.Journal of Education Mahasarakham University.175-187.

[21] Attasart Wiengsong, Sanit Kayapart and Wittaya Arreerard.(2010). The Developing Virtual Reality Media .Journal of Science and Technology Mahasarakham University.446-455.

[22] Augmented Reality in Education. Retrieved March 17, 2018, from https://thinkmobiles.com/blog/augmented-reality-education/

Biography

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