Interdisciplinary Research Review
Volume 15, Number 3, Pages 19 – 25

The development of online lessons to enhance practical skills with problem-based learning on microcontroller Arduino for undergraduate students

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Abstract

The purposes of this research were as follows: 1) to develop the online supplementary lessons to enhance practical skills with problem-based learning on Microcontroller Arduino for undergraduate students, 2) to evaluate the quality of the online supplementary lessons, 3) to compare the academic achievement of the learners before and after learning, and 4) to evaluate the satisfaction of the learners towards the online supplementary lessons. The sample group were 30 first-year undergraduate students of Computer Education of Nakhon Pathom Rajabhat University who enrolled in the 2/2019 semester selected by purposive sampling. The research apparatuses were as follows: 1) the online supplementary lessons on Microcontroller Arduino, 2) the online supplementary lessons' quality assessment forms, 3) pretests and posttests, and 4) the satisfaction assessment forms of the learners. The statistics used in data analysis were mean, standard deviation, and t-test statistics. The research found that 1) the online supplementary lessons to enhance practical skills with problem-based learning on Microcontroller Arduino for undergraduate students of Computer Education of Nakhon Pathom Rajabhat University had the quality of content and media production at a very good level ($\overline{X}$ = 4.53, S.D. = 0.57), 2) the academic achievement of the learners after learning was statistically significantly higher than before learning at 0.05, and 3) the overall satisfaction of the learners was at the highest level ($\overline{X}$ = 4.52, S.D. = 0.59).

Keywords: Arduino, microcontroller, online lesson, practical skills, problem-based learning
Article history: Received 30 April 2020 Accepted 18 May 2020

1. Introduction

Nowadays, Internet of Things (IoT) has been one of the life essentials as we connect to the internet more, we are more confident to control in major parts of life such as Smart Home or Smart Farming [1]. The development of IoT had been spreading into several aspects especially in industrial field which promotes value for the transportation business. Electronics could be connected both wire and wireless via Bluetooth that enhanced data processing that has developed the capabilities of the device to be smaller but more effective as well as designing IoT up to date products and support the convenience for users to use more easily [2]. IoT technology that will be applied will be divided into 3 sections; 1) Technology makes everything aware of information as interacting or approaching such as sensor that detects and reacts the input that are light, movements, humidity, pressure, etc. 2) the technology allows everything to communicate for example embedded system that was found in electric appliances by using the chip that follow the instruction or using the Microprocessor as well as Bluetooth, Low Power Wide Area Network (LPWAN) etc. These is the low energy consuming but provides a wide range of connection and 3) Technology assists everything to process information such as Cloud Computing which allows processing power storage unit and various online programs from service providers and the most known is Big Data Analytics, a process of analyzing large data to find the link patterns of those data while the results of the analysis can lead to effective business planning [3].

Microcontroller is the most famous used in electric appliances by embedded itself inside the appliances such as automatic washing machine, electric oven, microwave oven, air conditioning, these specify the temperature factor. While Arduino is to use various IC microcontroller in aspects of using C language together that was written to enable the operation of different microcontrollers as well as can use the same code. The

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project has released a variety of experimental boards in order to conduct with IDE itself Arduino as the most famous platform to operate both hardware and software due to the low cost of creating circuits in which the microcontroller operation must consist of 2 components; Hardware - machine and Software - programming platform of Arduino. The design is to offer a user-friendly without having any programming intellectual but only chosen Arduino and its feature. [4]

Arduino was developed in Ivrea, northwestern Italy in 2005 by Massimo Banzi and David Cuartielles. They intended to create cheap microcontroller devices that students can access then it was bought to be the owner. The small factory in this city was used as the first production of the Arduino board, the project name Arduino of Ivrea Arduino used to develop electronic devices prototype that designed to be easy to use, both hardware and software. The target consumers are inventors, designers who are interested in inventing innovations or creative work. In addition to the price of the device being compared to other microcontrollers on the market, Arduino can also be developed by a free program as an Open Source condition. [5]

Students majoring in Computer Education, Nakhon Pathom Rajabhat University enrolled in the second semester of the academic year 2019 had been assigned to study Innovation and Information Technology Course for Educational Communication and Learning subject regarding to the basic foundation of circuit system and other concern devices applying with the theory and emphasis on the practical way. This is to combine the practical and theory together further the boundaries of classroom.

The National Education Act of A.D. 1999, Chapter 4, Educational Management Guidelines, Article 24 describes the organization of the learning process. The educational institutions and related agencies should arrange the content and activities in accordance with the aptitude and interest of the learners, taking into account differences between people. Thinking process, management, coping, and applying knowledge to prevent and solve problems, encouraging instructors to organize the educational environment media and facilities for the learners to learn. Thus, teaching and learning are necessary to change the teaching and learning process that is based on teachers as the center for transferring knowledge by lecturing to organizing the learning process in accordance with the principles of the National Education Act, especially section 24 group 2 regarding practicing thinking and management process, encountering circumstances, and adapting knowledge to solve problem and section 24 group 3 regarding organizing activities for learners to learn from real experiences, love reading, and continuous curiosity to learn. [6]

The problem based is the cooperative learning in 21st century that emphasis center learner model. The learner will be group into 5-8 students per 1 teacher or another facilitator. This model begins with a significant problem as to simulate the future real world situation without a prior preparation; scenario or problem. In order to find reason and stimulus students to practice thinking and reasoning to explain by attempting to solve basic problems by using the same basic knowledge. Everyone has to set a base resolution along with considering and establishing the objectives of the study to find necessary knowledge. Along with considering and establishing the objectives of the study to find necessary knowledge to help to prove the hypothesis. After that, the group of students will disperse to study with various methods according to the objectives that have helped each other and then bring the newly added information. According to the objectives that have been set aside and then bring new additional information are reversed back to help summarize the assumptions to solve problems. [7]

Online lessons (e-learning) is the application of technology in teaching and learning by using multimedia technology to create content and produce teaching materials according to the needs of the students through online lessons which will make the learners to be able to access to the content and understand more easily and form learning process all the time.[8] Using online lessons increases motivation for learners and it is an exotic experience, a virtual addition and inspire learners to learn, do exercises and activities. It conveys content in the form of images, animations, text graphics and sound. There is also a direct interaction between the computer and the learner in order to create motivation in learning, making students more excitement and fun. [9]

According to the importance and the problems mentioned above, the researcher therefore had an idea to enhance learning achievement by using online skills media on the initial Microcontroller Arduino cope with problem based management. Students majoring in Computer Education, Nakhon Pathom Rajabhat University who enrolled in the second semester of the academic year 2019 were assigned to study Computer Educations Subject as they were required to create media for learning skills in connecting the sensor circuit to the Arduino uno r3 board and can write programs to control various devices and solve the problems that the teacher set up. The students can study by themselves or find more from the website, with instructors to offer an advice. This process would help students to think and analyze systematically as well as understand the functional design enable learners to create knowledge by themselves in the future.

2. Objective

1. To develop an online lessons skills development on Microcontrollers Arduino basic with problem-based learning on Innovation and Information Technology Course for undergraduate students.

2. To evaluate the quality of the online lessons.

3. To compare the learning achievement of learners before and after learning with the online lessons on the Microcontroller Arduino basic with problem-based learning for undergraduate students.

4. To assess learners' satisfaction towards the online lessons on Microcontrollers Arduino basic with problem-based learning for undergraduate students.

3. Hypothesis

1. The quality of the media enhances the online lessons of the initial Microcontroller Arduino basic that has been evaluated by 5 experts for undergraduate students is in good level.

2. Achievement of learners before and after learning with the online lessons on the Microcontroller Arduino basic with problem-based learning for undergraduate students gains a higher value than before learning with statistical significance at .05.

3. Students' satisfaction towards the online lessons on the initial Microcontroller Arduino basic with problem-based learning for undergraduate students is in a high level.

4. Scope of the Research

1. Research plan

This research is an experimental research. The researcher used the research plan of one group pretest-posttest design which has the details as follows:

Table 1. One group pretest-posttest design.

Samples Group	Pretest	Experimenting	Posttest
E1	T1	X	T2

E1 = Samples Group
T1 = Pretest
X = Experimenting
T2 = Posttest

2. Population and sample

2.1 The population in this research was 360 students of Computer Educations who enrolled in the academic year 22/019.

2.2 The samples in the research were 30 of first year students majoring in Computer Education. Students enrolled in academic year 2/2019, and were selected by simple random sampling.

3. Variables to be studied

3.1 The independent variable was the online lessons on the initial Microcontroller Arduino basic with problem-based learning for undergraduate.

3.2 The dependent variables included academic achievement and the satisfaction of learners.

4. The content was the Innovation and Information Technology Course for undergraduate students; in this research, the researcher has designed the lessons in practice on Microcontroller Arduino basic to conduct 3 units of experiment, which are;

4.1 Connection of Microcontroller Arduino to LED Lamp.

4.2 Connecting the Microcontroller Arduino with soil moisture sensor.

4.3 Connection of Microcontroller Arduino to I2C LCD Display.

5. Methodology

This research study was the development of the online lessons on Microcontroller Arduino with problem-based learning of students majoring in Innovation and Information Technology Course for undergraduate students. The researcher conducted the research according to the ADDIE Model [10] as follows:

1. Analysis Stage: the researcher conducted the analysis as follows: Studied courses and course descriptions on Innovation and Information Technology Course, classified activities and analyzed the content and objectives of the course. Selected content, consisting of 3 units of study related to be developed study the problem-based learning and learning model, applied the design of online teaching and learning activities and studied the technology to be used in media development, including Webhost, Atom, Adobe Photoshop CS6, Camtasia 9, and Google from websites, documents as well as related research.

2. Design stage: the researcher carried out the design as follows:

2.1 Designed content learning units, quality assessment forms of the online lessons, the tests before and after learning, problem-based learning activities, and satisfaction assessment forms of learners.

3. Development stage: the researcher developed the followings:

3.1 Developed online skills and quizzes using webhost, Atom, Adobe Photoshop CS6 and Camtasia 9, and brought webhost online learning materials.

3.2 Developed a media quality assessment form to enhance the online skills of the Microcontroller Arduino Introduction to content and media production techniques. Presented to 5 experts for quality evaluation.

3.3 Developed a test before class and after class.

3.3.1 The researcher created 50 items, with 5 experts evaluating the accuracy of the questions (IOC). The results showed that the test passed the criteria of 44 items with the IOC = 0.83 and the test was applied to find the difficulty and the power of discrimination.

3.3.2 The researcher brought 44 items to find the difficulty and the power of classification with the second year students in the Computer Education. It was found that the test has passed 35 items long criteria with the difficulty (P) = 0.65 and the classification

power (D) = 0.48 and the test to find confidence in the next order.

3.3.3 The researcher selected 30 items from 44 items to find the reliability of the whole set of tests. It was found that the test had a reliability of 0.72, which is in the appropriate criteria. This shows that this set of tests can be used in research

3.4 Developed students' satisfaction assessment form using a rating scale with5 levels [11];

5.00 = the highest level
4.00 = high level
3.00 = medium level
2.00 = low level
1.00 = the lowest level

4. Implementation: the researcher conducted the experiment and applied as follows:

4.1 Explained how to access to online skills enhancement media and the problem-based learning

4.2 Required students to do a pretest before study.

4.3 Assigned learning and work, issues, discuss knowledge learned with classmates and teachers.

4.4 Required students to do the posttest after study.

4.5 Required students to do a questionnaire to assess the satisfaction of the learners about using online learning skills about Microcontrollers Arduino basic with problem-based learning for student studying Innovation and Information Technology Course for undergraduate students.

5. Evaluation: the researcher conducted the evaluation as follows:

Analyzed the data obtained from the experiment and to find the statistical values which are mean, standard deviation and t-test statistics, summary of the experiment results and writing a research report.

6. Results

1. The results of the development of online lessons on the initial Microcontrollers Arduino with problem-based learning for undergraduate students Consists of lessons as shown in Fig. 1 – Fig. 6.

Figure 1: Main menu.

Main Menu consists of 6 items as follows:

1) Instructions for using lessons
2) Pre-test
3) Post-test
4) Lab 1: Connection of Microcontroller Arduino to LED Lamp
5) Lab 2: Connecting the Microcontroller Arduino with soil moisture sensor
6) Lab 3: Connection of Microcontroller Arduino to I2C LCD Display

Instructions describe doing pretests, posttests, and 3 chapters' contents.

Figure 2: Instructions for using lessons.

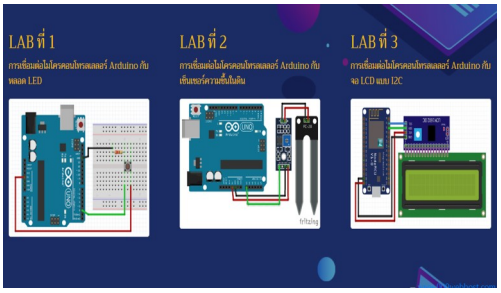

Figure 3: lesson.

Figure 4: Lab 1: Connection of Microcontroller Arduino to LED Lamp.

Each lesson has the teaching video for the learners to be able to learn and practice by themselves.

2. The results of the online lessons quality assessment are shown in Table 2.

From Table 2, it was found that the quality of the online lessons, evaluated by 5 experts was an average of 4.53 and a standard deviation of 0.57.

3. The comparison of learning achievement of students before and after learning with online lessons

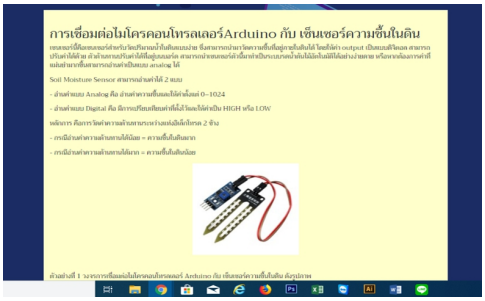

Figure 5: Lab 2: Connecting the Microcontroller Arduino with soil moisture sensor.

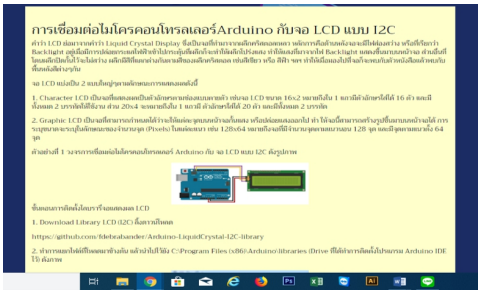

Figure 6: Lab 3: Connection of Microcontroller Arduino to I2C LCD Display.

Table 2. The results of the online lessons quality assessment.

Evaluation	Results		Level
	Average	S.D.	
Content	4.43	0.59	Good
Media Production	4.62	0.54	Very good
Total	**4.53**	**0.57**	**Very good**

on the initial Microcontroller Arduino with problem-based learning for undergraduate students is presented below in Table 3.

Table 3. The comparison of learning achievement of students.

Test score	N	Total Score	$\overline{X}$	S.D.	t	sig
Before learning	30	30	15.20	3.80	5.47	.000**
After learning	30	30	26.67	1.93		

** With statistical significance at the level of .05

From Table 3, it was found that learners' learning through online lessons had academic achievement of post study as (= 26.67, S.D. = 1.93) which is higher than pre study as (= 15.20, S.D. = 3.80). Moreover, the statistical significance was at the level of .05 which is in accordance with the set hypothesis.

4. The results of the assessment of students' satisfaction towards the online lessons are shown in Table 4.

Figure 7: Teaching Video.

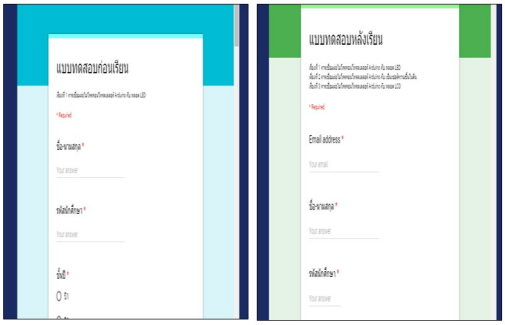

Figure 8: Pretest and Posttests.

Table 4. The results of the assessment of student satisfaction.

Question item	Results		
	$\overline{X}$	S.D.	Level
Contents			
1. Content consistent with purposes	4.67	0.57	highest
2. Clear explanation	4.53	0.37	highest
3. Suitable sequence of content	4.30	0.49	high
4. Suitable language	4.06	0.69	high
5. Clear questions and answers	4.83	0.59	highest
Average	**4.48**	**0.54**	**high**
Techniques			
6. Font, size, and color of letters	4.43	0.67	high
7. Background	4.23	0.68	high
8. Sound and animation	4.55	0.96	highest
9. Interaction with users	4.96	0.68	highest
10. Beauty	4.54	0.47	highest
Average	**4.54**	**0.69**	**highest**
Problem-based Learning			
11. Various activities	4.65	0.56	highest
12. Interesting learning	4.96	0.78	highest
13. Learners take part in assessment	4.56	0.31	highest
14. Sharing experience with friends and instructor	4.13	0.68	high
15. Can study by yourself all the time	4.46	0.50	high
Average	**4.55**	**0.56**	**highest**
Total	**4.52**	**0.59**	**highest**

From Table 4, it was found that the students were satisfied with the highest level ($\overline{X}$= 4.52, S.D. = 0.59)

when considering each aspect, it was found that the content was at a high level of satisfaction ($\overline{X}$= 4.48, S.D. = 0.54).Furthermore, the technical production was at the highest level ($\overline{X}$= 4.54, S.D. = 0.69) and the problem-based learning and activities were also at the highest level ($\overline{X}$= 4.55, S.D. = 0.56).

7. Conclusions

1. The quality of the media enhancing the online skills of the initial Microcontrollers Arduino with problem-based learning on Innovation and Information Technology Course for undergraduate students evaluated by 5 experts was at a very good level with an average of .4.53 and a standard deviation of 0.57 which is in accordance with the assumption.

2. Achievement of learners before and after learning with online lessons about Microcontrollers Arduino, basic with problem-based learning on Innovation and Information Technology Course for undergraduate students had higher academic achievement after studying with statistical significance at the level of.05 in accordance with the assumptions set.

3. Overall, students' satisfaction with the online lessons on the initial Microcontroller Arduino with problem-based learning on Innovation and Information Technology Course for undergraduate students, was the highest level ($\overline{X}$=4.52, S.D.=0.59) which is in accordance with the hypothesis set.

8. Disscussion

1. Learning achievement of learners after learning by online lessons had higher academic achievement than before learning with statistical significance at the level of .05 in accordance with the assumptions set. That is because the research has passed the evaluation process of media quality from 5 experts which was suitable before being applied in the class. The media quality included the online lessons consisting of content, practice, that are colorful and able to attract the attention of learners, and activities to practice which are agreeable with the research of Kriangsak Ploysang [12] who studied learning achievement in language courses and communication using problem-based learning, found that the learning achievement in teaching language courses and communication that use problem-based learning as the base after learning is higher than before study with statistical significance at the level of .0.

In addition, it is also in line with the research of kinnaree Chian, Piya Supavarasuwat, Wisult Sunthonkanokpong and Sunti Tuntrakool [13] who conducted the research on the internet based tutorial lesson on cable TV, found that when the pretest and posttest scores of the students were compared, the average score of posttest was statistically higher than that of the pretest at .01 level.

2. Learners' satisfaction with online skills enhancement media titled Microcontrollers Arduino basic with problem-based learning on Innovation and Information Technology Course, was at the highest level with an average of 4.52 and a standard deviation of 0.59 as online lessons enabled students to learn anywhere and anytime. It made learners to be more comfortable in learning and understand contents by themselves. Each content in each chapter was suitable and made students enjoyable in learning. The findings are agreeable with the research of Zacharis [14] as learners can elastically work together resulting in the learners to have good quality works, better records, and satisfaction towards teachings.

9. Recommendation

1. General Recommendation

1.1 Learners have better academic achievement due to the learning by using online skills enhancing media about Microcontrollers Arduino with problem-based learning on Innovation and Information Technology Course. The researcher thinks that this online skill-enhancing media should be used for other learning management, including project-based learning.

1.2 Online lessons can help learners practice. This can increase skill which is suitable for practical subjects which can practice through online lessons at any time but may add activities or exercises or more diverse games to meet the different learning needs of learners. In addition, exercises that are diverse should be added. Importantly, it must be suitable with the content, objectives and needs of learners.

2. Suggestions for further research

2.1 The online lessons from this research should be adopted and incorporated into online lessons of a subject in order to enhance and develop teaching activities more effectively by using technology.

2.2 The online lessons from this research should be developed in order to be able to be used on the online platform of a portable device.

2.3 Should be a sound of motion picture that have video clips in order to be more interesting.

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