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ENGINEERING DESIGN PROCESS WITH CLOUD BASED LEARNING MANAGEMENT TO ENHANCE INNOVATION SKILLS AND CREATIVE PRODUCT

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ABSTRACT

The objectives of this research were to 1) develop an engineering design process with cloud-based learning management to enhance innovation skills and creative product and 2) investigate the academic results using an engineering design process with cloud-based learning management to enhance innovation skills and creative product. The sample were 52 Southeast Bangkok College students majoring in computer technology, who registered for an embedded system and application subject and divided into two groups: a control group and an experimental group. The research results found 1) an engineering design process with cloud-based learning management to enhance innovation skills and creative product had eight steps : 1. Define the Problem, 2. Gather Information, 3. Generate a Solution, 4. Analyse the Solution, 5. Select a Solution, 6. Implement Solution, 7. Evaluation and, 8. Reflection and 2) Post study, the experimental group had higher scores innovation skills and creative product than the control group and the criteria.

Keywords: *Engineering Design Process, Cloud Based Learning, Innovation Skills, Creative Product*

1. INTRODUCTION

Today information communication technology is used to support people's daily routines and operations in different industries, such as medical, agricultural, industrialized and education industries [1]. In addition, various types of information and knowledge are distributed digitally over the network system [2]. Hence, educational institutions at all levels are required to provide students with information and abilities in a variety of areas that are relevant to changes in the 21st century, especially innovation skills. This is because innovation skills are basic skills that could support people's routines and operations. The skills also help students to make creative products. Thus, educational institutions have to develop learning models adapting technology to make it modern, flexible, interesting [2] and supportive towards learning, activity and communication between the lecturer and the student.

The engineering design process was viewed as a learning paradigm that facilitated learning, action and communication. Furthermore, it helped students establish knowledge structure and comprehension of engineering design. The engineering design process was considered as a learning paradigm that promoted learning, activity and communication. Furthermore, it helped students to establish knowledge structure, comprehension of engineering design [3], [4], [5], new engineering design and the solutions to solving problems [6]. Each process supported the students to help students improve their 21st century skills by requiring them to apply their knowledge in a variety of sectors and conduct experiments [7], in order to create a creative product as set by the instructor.

Cloud-based learning management is the learning management system of the 21st century that supports the learning process of both the lecturer and the student efficiently and conveniently [8]. It includes six main systems: 1) Course Management, 2) Content Management, 3) Test and Evaluation System, 4) Course Tools, 5) Data Management System and, 6) Simulation Management System [9], [4], [10]. From the policy of the industrialization 4.0 era, which the old teaching model cannot respond to, it is necessary to develop a new teaching model to respond to the national policy. Therefore, the researcher decided to develop transformative learning with digital fabrication laboratory to enhance innovation competency and creative product, as a means of supporting digital learning and technological practice [15] in order for students to have the skills to be able to enter the labor market in the future.

According to the concepts and principles above, the researcher decided to develop an engineering design process with cloud-based learning management to enhance innovation skills and creative product by the integration of cloud-based learning management. This would involve different activities to create learning, interaction and knowledge exchange among students under the environment that included a learning management system, via tools and technology, to connect and relate a variety of knowledge in different fields, and to demonstrate the operation on the network, in order to build innovation skills for students to create creative product. Furthermore, the researcher would like to study the academic results by the integration of engineering design process with cloud-based learning management to enhance innovation skills and creative product.

2. RESEARCH QUESTION

1. What was earning management to enhance innovation skills and creative product?

2 How was the academic results using an engineering design process with cloud-based learning management to enhance innovation skills and creative product?

3. OBJECTIVE OF THE STUDY

1. To develop an engineering design process with cloud-based learning management to enhance innovation skills and creative product.

2. To investigate the academic results using an engineering design process with cloud-based learning management to enhance innovation skills and creative product.

4. CONCEPTUAL FRAMEWORK

In this step, the researcher would like to discuss the development of concept framework engineering design process with cloud based learning management to enhance innovation skills and creative product. The researcher has studied, analysed, synthesized and integrated the relevant documents and articles regarding the engineering design process [11], [12], [13], cloud based learning management [9], [4], [10], innovation skills [14], [15], [16] and creative product [3], [17], [18] in order to develop the model of an engineering design process with cloud based learning management to enhance innovation skills and creative product. This model has eight steps : 1) Define the Problem, 2) Gather Information, 3) Generate a Solution, 4) Analyse the Solution, 5) Select a Solution, 6) Implement Solution, 7) Evaluation and, 8) Reflection [11], [12], [13]. Each step helps the students to apply their gathered knowledge in different fields, and to conduct experiments [7] as shown in Figure 1. The details of each step are as follows:

1. Define the Problem

The students studied the 10-unit contents of a microprocessor course via a cloud-based learning management system using Google classroom; a cloud social tool. After the students completed each unit of the course in the limited time, the instructor would define the problems and give questions to each student group. The students were divided into groups using a jigsaw technique to help each other in designing, developing and demonstrating their project as set by the given questions. Brainstorming was made through course tools. Cloud social tools such as Line, Facebook and Google Meeting were used for students to exchange their opinions and ideas with each other. The instructor also used cloud social tools to give advice and suggestions.

2. Gather Information

Each student in the group had to study by researching the information from different sources on the internet system. The students also had to share information to find the solution for questions given by the instructor, by using social media channels. Then, each group of students would share their opinions regarding the gathered information from various sources to find the solution via course tools, or cloud social tools such as Line, Facebook and Google Meeting. The gathered data would be stored and recorded through data management systems by using Google Drive, One Drive and Dropbox.

3. Generate a Solution

The students in each group would apply the gathered information to create a flow chart, and share their opinions within the group to summarize students' opinions. They would explain this by using the illustration that the students developed as the objectives which integrated the operation simulation tools, equipment placement, circuit connecting and circuit tools configuration via a simulation management system. This was done by using cloud social tools, Canva and Draw.io.

4. Analyse the Solution

Students analysed the possibility and feasibility of the solutions to create the project that

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could operate according to the goals set by the group. The students could use course tools to explain the operation process of the project by writing the description, searching for the references, defining command codes of flow chart operation sequences by integrating Line, Facebook and Google Meeting.

5. Select a Solution

The students from each group shared their opinions to find and select the best solution as the instructor and the instructor's assistant gave them advice regarding the feasibility of each solution on Line, Facebook and Google Meeting. The solution was required to be able to develop the project to be operative as set by the given questions.

6. Implement Solution

This step referred to the project development using microcontroller via tools of Tinkercad and Arduino IoT Cloud, and circuits that were assembled from electronic devices. There were four steps to developing a creative product: 1) Assembling; students had to connect electronic devices and a microcontroller, 2) Coding: students had to create the program using C programming language from tools like Arduino IoT Cloud and Tinkercad via a simulation management system, 3) Compiling: students compiled the set of commands to verify them, and 4) Testing: students tested the operation of the command set together with electronic devices and the microcontroller board of Arduino, with the help and advice provided by the instructor via course tools like Line, Facebook and Google Meeting.

7. Evaluation

Students used the coud social programs of Live Worksheets ad Google Form to write down solutions and solve the given questions via a test and evaluation system. Then, they sent the answers to the cloud learning system through Google Classroom. After that, the instructor would set the presentation dates for each group, as the students had to present on the selected dates. The instructor also had to evaluate students using criteria of creative product that were developed and evaluated by the experts.

8. Reflection

The instructor let the students of each group summarize the solutions of the given questions on report. The report included contents of the problem background, objectives, steps to problem solving, results, advantages and disadvantages of solutions, and obstacles. The students could use Prezi, Canva and Capcut to create videoclips to explain the operation of the developed creative product, then present them through course tools for the instructor to evaluate the project. This also allowed other students in the classroom to share their opinions and suggestions towards the questions, which helped students in other groups to study and apply their knowledge on the next questions.

5. RESEARCH METHODOLOGY

This research included 2 process:

Process 1: To develop an engineering design process with cloud-based learning management to enhance innovation skills and creative product. After the concept framework for this study had been developed, the researcher developed an engineering design process with cloud-based learning management and a system. The form was evaluated using Black box.

Process 2: To investigate the academic results using an engineering design process with cloud-based learning management to enhance innovation skills and creative product. In this research is quasi-experimental, conducted with 52 undergraduate students of the Division of Computer Technology of Southeast Bangkok College who enrolled to study the subject of embedded systems and applications. The researcher used simple random sampling to arrange students into groups, with 26 students per group. Students in the experimental group studied using the engineering design process with cloud-based learning management to enhance innovation skills and creative product. The students in the control group studied in a traditional teaching-learning setting by the instructor used a lecture-based teaching method in class. And have students complete a worksheet each week. The students must design and create creative works to submit in class.

6. RESEARCH TOOLS

The researcher created 2 evaluation forms: 1. Innovation Skills and 2. Creative Product. The innovation Skills form was adapted from the evaluation test of Keinanen et al. [19] and has 5 competencies: 1) Creative problem solving 2) Systems thinking 3) Goal orientation 4) Teamwork and 5) Networking. This evaluation of innovation competency has 20 question and is a five-point self-assessment. The creative product was created by the adaptation of 4 levels of rubrics according to the concept of Besemer and Treffinger [20] and Wongwanich [21].

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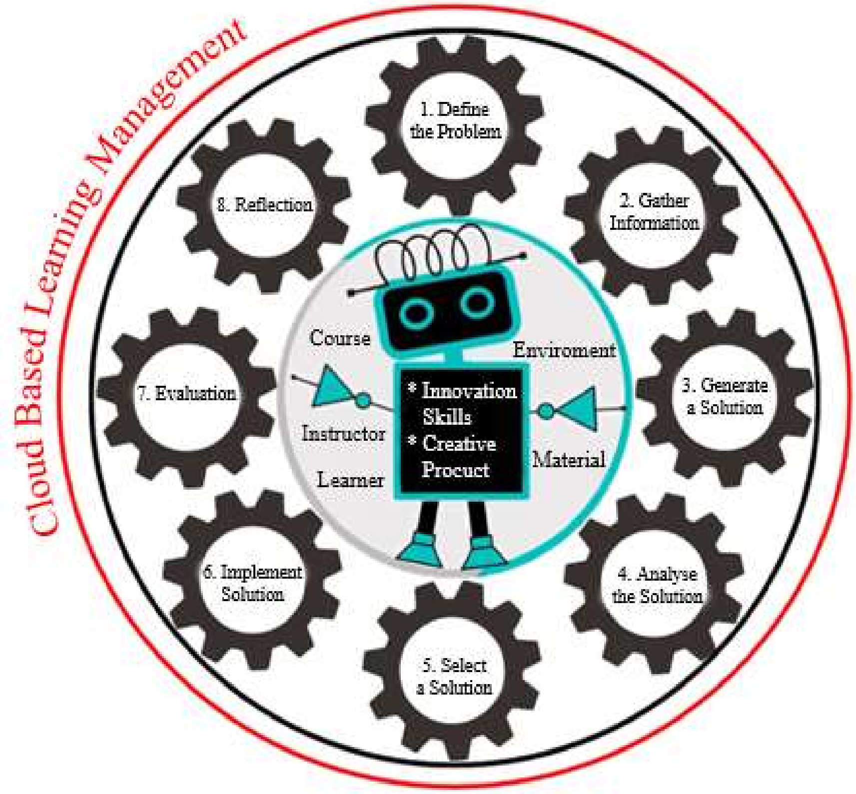

Figure 1: Process of transformative learning

This evaluation forms, adjusted according to the thrid expert group. They were used as the data gathering tool to check content validity and determine the index of item objective congruence (IOC). The consistency between the questions and the intended purpose was measured by the experts' opinions on each question, with +1 indicating consistency, 0 - not sure and -1 indicating lack of consistency all the questions were rated as +1, hence they were consistent with the intended purpose [22]. The reliability of Innovation Skills is 0.87 and Creative Product has an intercorrelation value of 0.89.

7. VARIABLES IN THIS STUDY

1. Dependent variables were the innovation skills and the creative product.

2. Independent variable was the system of engineering design process with cloud-based learning management.

8.RESEARCH HYPOTHESIS

In this study, the researcher set 3 hypotheses as follows:

Hypothesis no. 1: After taking the subject, the experimental group had higher innovation skills and better creative product scores than the control group.

Hypothesis no. 2: After taking the subject, the experimental group had higher innovation skills scores than the standard of 70 percent.

Hypothesis no. 3: After taking the subject, the experimental group had a higher creative product score than the standard of 70 percent.

9. DATA ANALYSIS

Hypothesis no. 1 use MANOVA and Hypothesis no. 2 and 3 use one sample t test to analyse the data.

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10. RESEARCH RESULT

The researchers would like to present the results of their research according to the research objectives as follows.

1. An engineering design process with cloud-based learning management to enhance innovation skills and creative product consisting of eight steps: 1) Define the Problem, 2) Gather Information, 3) Generate a Solution, 4) Analyze the Solution, 5) Select a Solution, 6) Implement Solution, 7) Evaluation and, 8) Reflection. Evaluation results of a suitability evaluation of the concept framework of the engineering design process with cloud-based learning management to enhance innovation skills and creative product by seven experts who had 1) an Engineering doctoral degree (3 experts) and Information and communications technology doctoral degrees (4 experts) and, 2) five years or more experience in teaching embedded systems and information and communications technology. Purposive sampling was used to select the sample for this study. The overall score of suitability was at the highest level ($\overline{x}$ = 4.85, S.D. = 0.21). This could be posited that the steps of the conceptual framework of the engineering design process, with cloud-based learning management to enhance innovation skills and creative product, could be used as the guidelines to create a practical learning system to develop innovation skills for students to build a creative product. ผลการประเมิน an engineering design process with cloud-based learning management and a system by the second group of 5 experts who had 1) engineering doctoral degrees (2 experts) and information and communication technology doctoral degrees (3 experts) and, 2) five years or more experience in teaching embedded systems and Information and communications technology. The sample for this study was selected via purposive sampling. The mean of the overall score was at the highest level ($\overline{x}$ = 4.52, S.D. = 0.47), which showed that this system was practical for learning and teaching.

2. The academic results using an engineering design process with cloud-based learning management to enhance innovation skills and creative product.

The three findings of this objective according to the three hypotheses were as follows:

Hypothesis no. 1: After taking the subject, the experimental group had higher innovation skills and better creative product scores than the control group.

The researcher had checked the required conditions of one-way MANOVA in terms of 1) homogeneity of covariance matrix and covariance of variables by using Box's M Test. The result stated that the covariance matrix and covariance of innovation skills and creative product scores after students, in both the experimental group and the control group took the subject, were not different in significance value. 2) Moreover, after checking the homogeneity of the covariance matrix of each variable between both groups, using Levene's test, innovation skills and creative product scores after the students took the subject had the same variance of population. 3) By checking the relationship of each variable using Bartlett's Test of Sphericity after classifying the group variance-covariance matrix to be the experimental group and the control group, the difference was not null at the significance level. Therefore, the scores of the innovation skills and the creative product of both experimental and control groups after taking the subject were related at significance level. This meant that the data could be analysed using one-way MANOVA as shown in Table 1.

Additionally, the researcher had analyzed the mean of innovation skills and creative product scores after students in both experimental and control groups took the subject. The mean scores of innovation skills and creative product of both student groups were revealed to be different at significance value of 0.05. After students in both groups took the subject, the experiment group also had higher innovation skills and creative product scores than the control group at 18.770 and 8.846, respectively. This outcome was in line with the predicted hypothesis as shown in Table 2. The scores with regard to innovation skills and creative product after both experimental and control groups had taken the subject are illustrated as shown in Figure 2.

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Table 1. Mean and standard deviations of innovation skills and creative products scores after students in both experimental and control groups took the subject.

Variable	Experimental group		Control group		Leven's statistics (p)	Box's M (p)	Bartlett's χ2 (p)
	x̅	S.D.	x̅	S.D.			
Innovation Skills	81.385	3.623	62.615	4.401	0.155 (0.695)	6.385 (0.106)	14.775 (0.001)
Creative Product	77.885	1.796	69.039	2.705	2.315 (0.134)		

Table 2. The results of Multivariate Analysis of Variance (MANOVA) of innovation skills and creative product scores of experimental and control groups

Independent variable	Statistics		Value	Approximate F		p
Group	Pillai's Trace		0.906	236.933		0.000
	Wilks' Lambda		0.094	236.933		0.000
	Hotelling's Trace		9.671	236.933		0.000
	Roy's Largest Root		9.671	236.933		0.000
Tests of Between-Subjects Effects						
Dependent variable	SS	df	MS	F	p	Post Hoc test
Innovation Skills	4579.692	1	4579.692	281.894**	0.000	1>2
Creative Product	1017.308	1	1017.308	192.953**	0.000	1>2

Note :** P < 0.01

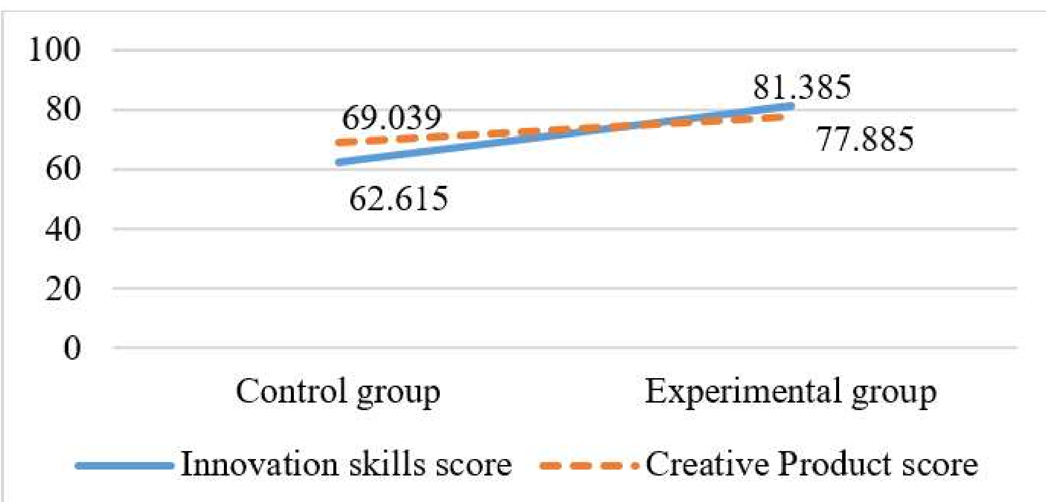

Figure 2: Innovation skills score and Creative Product score

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Hypothesis no. 2: After taking the subject, the experimental group had higher innovation skills scores than the standard of 70 percent.

The findings showed that, after taking the subject, the experimental group students had an innovation skills score at 81.385. The policy of computer technology major in Southeast Bangkok College stated that the students were required to have innovation skills scores higher than 70 percent. From this could be inferred that, after students in the experimental group took the subject, the group had a higher innovation skills score than the requirement at significance level of 0.05. The students in the experimental group also had a higher innovation skills score than the required standard at 11.385. This was in line with the hypothesis as shown in Table 3.

Hypothesis no. 3: After taking the subject, the experimental group had a higher creative product score than the standard of 70 percent.

The research findings indicated that, after taking the subject, the experimental group had a creative product score of 77.885. Southeast Bangkok College's computer technology major policy stated that students needed to obtain creative product scores higher than 70%. Therefore, the students in the experimental group had higher creative product scores after taking the subject at a significance level of 0.05. Moreover, the experimental group also had higher creative product scores than the required standard of 7.885. This corresponded to the forecasted hypothesis as shown in Table 4.

11. DISSCUSSION

1. The overall evaluation of the engineering design process, using cloud-based learning management to improve innovation skills and creative products, was rated as the highest. This is because the researcher studied, synthesized and integrated the relevant articles and concepts about the Engineering Design Process [11], [12], [13] Cloud Based Learning Management [9], [4], [10] Innovation Skills [14], [15], [16] and Creative Product [3], [13], [18] to develop eight steps of the engineering design process with cloud-based learning management to enhance innovation skills and creative product. The eight steps were : 1) Define the Problem, 2) Gather Information, 3) Generate a Solution, 4) Analyse the Solution, 5) Select a Solution, 6) Implement Solution, 7) Evaluation and, 8) Reflection. Each step could help students to apply their gathered knowledge in different fields and to conduct experiments [7].

2. After taking the subject, the experimental group had a higher mean innovation skill and higher creative product scores than the control group, because the experimental group studied the engineering design process with cloud-based learning management to enhance innovation skills and creative product, which supported the students to improve their innovation skills [18], [23]. This led to the creation of the creative product [24], [25][26]. Unlike the experimental group, the control group studied in a traditional teaching-learning setting. It could be said that there was not any process to improve the control group's innovation

Table 3. Innovation skills score after taking the subject compared to the required score.

Group	Amount	$\bar{x}$	S.D.	Criterion	t	Sig
Experimental group	26	81.385	3.623	70	16.023**	0.000

Note :** P < 0.01

Table 4. Creative product score after taking the subject compared to the required score.

Group	Amount	$\bar{x}$	S.D.	Criterion	t	Sig
Experimental group	26	77.885	1.796	70	22.383**	0.000

Note: ** P < 0.01

skills to create a creative product. Thus, the experimental group had a higher mean innovation skill and higher creative product scores than the control group, which was in line with the research of Sreejun & Chatwattana [24], Sopapradit [26], Sopapradit & Wannapiroon [27] and Yoosomboon & Piriyasurawong [28].

3. After taking the subject, the experimental group earned a higher score for innovative skills than the benchmark of 70%, because engineering design process with cloud-based learning management to enhance innovation skills and creative product helped the students to improve their innovation skills through eight steps of engineering design process with cloud-based learning management. These eight steps focused on the 21st century technology practices. Therefore, the experimental group had a higher mean innovation competency score than the criterion as required by the policy of the Southeast Bangkok College [29].

4. After taking the subject, the experimental group received a higher creative product score than the standard of 70%, because engineering design process with cloud-based learning management to enhance innovation skills and creative product was the learning system that enhanced and encouraged students to create a creative product continually through the eight steps of the engineering design process with cloud-based learning management. These eight steps helped students to develop a creative product. Hence, the experimental group received a higher mean creative product score than the criterion required by the policy of the Southeast Bangkok College [29], which stated that the college would like students to practice the lessons.

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