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STEM Learning Platform Using Design Engineering for Reinforcing Students' Computational thinking skills

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Abstract. This research aims to study STEM learning platforms using design engineering for reinforcing the computational thinking skills of the students to whom it is applied. The results showed that the study of STEM learning platform using design engineering for reinforcing the computational thinking skills of undergraduate students included the platform suitability evaluation. The evaluation showed that the quality of the content and the platform technique were in the highest level ($\bar{x}$ = 4.73, S = 0.26), and it scored 92.86/91.45 for platform efficiency determination. The comparison of the performance and the achievement of students' computational thinking skills from STEM education in collaboration with design engineering indicated that the academic achievement and computational thinking skills of students who studied with the STEM learning platform were higher than those of the students who studied with a normal learning approach. Student satisfaction towards the learning platform was in the highest level ($\bar{x}$= 4.89, S = 0.16).

Keywords: Computational Thinking Skills, STEM Education, Design Engineering, Students and Teachers of Thai Rajabhat University, Multivariate analysis of variance.

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INTRODUCTION

The Ministry of Science and Technology, Royal Thai Embassy, Washington D.C. (Ministry of Science and Technology, Royal Thai Embassy, 2013) said that STEM education learning originated in the United States of America, following low performance on the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), including the overall decreasing academic performance, the lack of attention, and the occupations which are not related to science, technology, engineering, and maths. Therefore, the government provides STEM learning management (Breiner et al., 2012). The application of STEM education also reinforces the development of essential skills in the globalized world, or essential 21st century skills (Dejarnette, 2012 : 77– 84). This conforms to (Sasithep. P, 2015) who said that learning management on science, technology, engineering, and maths is the learning management channel which provides students with the essential living skills for the 21st century. The PISA 2018 test will evaluate the education system and the teacher-to-student level of global-living competency support. The education system can learn how to receive and enhance the program, promote the teaching method and adjust teacher training in order to facilitate and develop global-living skills, and to support the global-living competency and global citizenship (OECD, 2015).

The teaching of STEM, focuses on teaching steps which comprise the identification of the problem, definition of the problem, planning, placing a contingency plan, implementation of the plan, and evaluation (Wasinee. I, 2016: 37). Teaching and learning principles of STEM education are: 1) focusing on knowledge integration of multiple subjects by teachers; 2) creating association by connecting and leveraging knowledge; 3) focusing on acquiring and applying 21st century skills, by teaching which generates creativity and teamwork; 4) teaching which challenges knowledge according to an age and class basis, and focuses on 21st century skills from multiple views, and 5) the integration of teaching, such as the use of project-based learning for the engineering teaching process. This conforms to (Jumras. I, 2011) which mentioned about STEM learning management that teachers should apply multiple learning styles to their teachings. For example, problem-based learning which allows an efficient search for a solution and application of knowledge to a defined situation where a challenging problem is formed. It also encourages students to seek knowledge, developing the teacher's professional learning in order to support learning management competency by using STEM education in fundamental education for a good understanding. It was also found that (Jaroonpong. C et al, 2018) STEM education which focuses on an engineering design process can solve the problem encountered, plan the problem-solving process, and check the errors, as well as identifying solutions to that problem resulting from the group's problem-solving process. This (Ubonwan. G et al, 2017) gives an inquiry-based online lesson platform with scaffolding which promotes computational competency. It was found that the overall suitability level of the platform is high. It can be concluded that the synthesised platform can be effectively applied as the teaching and learning model. This enhances students' learning competency in the 21st century and can be associated with the (Wijarn. P, 2012) saying that teachers need to be an inspirer, coach, and mentor for students. They also need learn together with their students by applying information technology and computer knowledges. It is (Ministry of Education, 2008) mentioned that the Basic Education Core Curriculum B.E. 2551 has defined the policy for developing youths in order to equip them for the 21st century world by focusing on promoting students' thinking skills, technology skills, and teamwork skills, so they can live peacefully in society, as well as applying knowledge and learning styles to their daily lives.

According to the mentioned significance and background, the STEM learning platform using design engineering for reinforcing computational thinking skills of Thai Rajabhat Universities' students and teachers for 21st century education needs to be developed. They must apply knowledge and competency to the teaching and learning which will correspond with educational changes in computing science in Thai society in the 21st century. Therefore, diverse learning types should be applied to the future class which conforms with (Arık, M. & Topçu, M.S. (2020), whose research found that different teaching methods were applied to the engineering design process, laboratory activities, and activity writing. It would be the guide for the researchers and teachers in planning and implementing the engineering design process in class. (Zhou. L et al, 2014) (Courtney. Goode , 2019) implemented the engineering design process which is the physical model of the particular solutions used in practical activities, planning, creating and several testing methods which can be efficiently applied to class.

Learning management of universities in Thailand has been being adapted for the 21st century education. It needs to develop an appropriate and diverse educational management platform. The STEM learning platform using design engineering for reinforcing the computational thinking skills of undergraduate students is developed by the researcher. Referring to the academics, a mutual teaching management problem was found in the subject, and project-based STEM learning was applied to the class. (Prarichat Reunpongpan, 2016) (Charinthorn. A, 2015) (Garunphol Wiwanthamongkol, 2018) (Jantarasena, V., & Asanok, M, 2020) (Nuttaya Eamkong, 2016) found that there was a lack of understanding and knowledge in the implementation of the majority of the content from the learning unit. Therefore, there should be available media for students to learn and review. For traditional learning, students are bored and inactive due to the difficulty and quantity of the content. Students need to have an understanding of the learning process which can be extended in the future. Students' academic performance is poor. It is below the standard and criteria of the quality assurance standard. Students lack competency in applying or searching for further knowledge and implementing it with their own projects. The lesson contents are important to the development of students' professional computer systems in the future. It allows them to apply skills and teaching management to their daily life, and encourages students to be able to manage the 21st century teaching. This is consistent with (UNESCO, 2008) (Panich. V, 2016) (Ministry of Education, 2008) who mentioned that it is necessary to collaborate, obtaining the cooperation of teachers and students for learning management. It is also necessary to apply knowledge on information technology and computers according to the Basic Education Core Curriculum B.E. 2551 in which the policy is to prepare the nation's youth for the 21st century world by focusing on the promotion of students' thinking skills, information technology, teamwork, and peaceful living in the world's societies. It also concentrates on the students' implementation of knowledge and the teaching platform to daily life.

Research Objectives

1. To develop a STEM learning platform using design engineering for reinforcing students' computational thinking skills.
2. To compare the academic performance and computational thinking between the students who study with the STEM learning platform using design engineering and the students who study with traditional learning platform.
3. To study the students' satisfaction towards the STEM learning platform using design engineering for reinforcing students' computational thinking skills.

LITERATURE REVIEW

Computational thinking skills

Computational thinking, according to many educators (Wing, 2006) (Cuny. J. et al, 2010), (Valerie Barr and Chris Stephenson, 2011) (O'Neil, T. L. et al, 2012) (Breiner, J. M., et al, 2012) (Lye, S. Y., & Koh, J. H. L, (2014) (Swaid, 2015) (Zhong. et al, (2016) (González-Pereira, et al, (2010) (Basogain. et al, (2017) (Angevine. C, 2 0 1 7) (Passkorn, C, et al, 2 0 1 8) is the ability to analyze and choose information from the repeated problems, defining the problem-solving process, and developing competency in designing problem-solving steps, evaluation, amendment of the mistakes, creation of work, and compatibility. There are 7 elements which are: the analysis competency in selecting information from the repeated problem; the ability to define the problem-solving process, the ability to design problem-solving steps, the competency in evaluation, the ability to fix mistakes, the ability to work with others, and the ability to create works. Computational thinking can be efficiently implemented in education: analysis, design, development, problem solving, evaluation, creating works, and systematically and efficiently working on computers. (Google for Education, 2018) has also been used for solving problems in all subjects consisting of maths, science, and humanities. (Humdani. S. K, 2 0 1 7) (Poovarawan. Y, 2 0 1 6) (Katalin. H., & Zolton. K., 2 0 2 0) (Giuseppe. C et al, 2 0 1 9) mentioned the advantages of computational thinking in education since it promotes creativity, work processes, rationales, and systematic work plans. It also encourages the systematic application of scientific knowledge to daily life.

STEM Education using Design Engineering

The educators applied and implemented STEM Education using DesignEngineering (Korkmaz. et al, 2017) (Mehwish. B et al, 2018) (Dasgupta. C et al, 2019) (Chiu. J. L et al, 2013) (Strobel. J, et al, 2013) for educational benefits. It increases multiple skills by generating attention and developing imagination in learning. It is suitable for all sexes and careers. Students have self-control skills by learning systematic analysis. It can also create an integrative learning environment. It allows students to solve complicated projects by applying a mathematical rationale with art design and technological skills, so the students can work in a practical manner.

METHODS

Population and Sample Group

1. The evaluation of the suitability of the platform – the respondents were the expert group.
2. The comparison of the skill and achievement of computational skill
3. The satisfaction with the platform – the experimental sample was the undergraduate students of Nakhon Pathom Rajabhat University. The sample group was randomized with a multi-stage sampling method to create two groups: the experimental group and the control group.

Research Tools

1. An evaluation form on the suitability of the STEM learning platform using design engineering was used to evaluate the suitability of the platform and is divided into 3 parts as the follows:

Part 1: The evaluation of the consistency of the STEM learning platform using design engineering for reinforcing computational thinking skills for the undergraduate students.

Part 2: The evaluation of the suitability of the STEM learning platform using design engineering for reinforcing computational thinking skills for the undergraduate students.

Part 3: The recommendations on the STEM learning platform using design engineering for reinforcing computational thinking skills for the undergraduate students.

2. The evaluation of lesson plan and online courses by validating the LMS lesson quality of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students. This includes a content evaluation form, and technique evaluation form of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students. For the content, a 3-level rating scale was used and can be divided into 2 copies, as follows;

Copy 1: Content evaluation form of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

Copy 2: Technique evaluation form of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

3. One copy of the computational thinking evaluation form was a performance-based evaluation form with 5-level rubric scoring (Somsak. P, 2001) (Nitko. J. A, 2004). Secondly, a multiple- choice objective test on academic achievement was used. After that, the reviewed computational thinking skills evaluation form was presented to 9 experts for content validation and construct validation by considering the Index of Item - Objective Congruence (IOC) using a 3-level rating scale evaluation form.

4. One copy of the 5-level Likert scale satisfaction survey (Likert, 1967) was categorized into 2 sections, as follows:

Section 1: General information of the questionnaire respondents (check list form)

Section 2: Survey on the satisfaction towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students. This was a 5-level rating scale survey with 4 evaluation elements consisting of lesson content, teaching media, learning activities, and evaluation.

Data Collection

The researcher 1) evaluated the suitability of the platform using a focus group with 9 experts, selected by the purposive sampling method, of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students; 2) checked the quality evaluation of the contents and technique of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students; 3) compared the skill and achievement of computational thinking skills of the sample groups: 40 students in the experimental group who studied with the STEM learning platform using design engineering and 40 students in the control group who studied with a normal learning platform, and 4) assessed the satisfaction with the platform: the control group was 40 students who studied with the STEM learning platform using design engineering.

Data analysis

Mean, standard deviation, the efficiency of the process (E1), the efficiency of the result (E2), and Interrater Reliability (IR) were used to analyze the data.

Research tools

1. In studying the STEM learning platform using design engineering, the researcher collected information from documents, textbooks, and related studies.

2. A focus group was used to check the platform in order to evaluate the suitability of the STEM learning platform using design engineering. One copy of the evaluation form on the suitability of the STEM learning platform using design engineering was used and it was divided into 3 sections, as follows:

Section 1: The evaluation of the Index of Item - Objective Congruence (IOC) of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

Section 2: The evaluation of the suitability of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

Section 3: The recommendation for the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

by presenting the suitability evaluation form to the thesis advisor to validate and adjust for better content. The revised form was then presented to the 9 experts for content validation by considering the Index of Congruence (IOC) and definitions using a 3-level rating scale evaluation form. The score criteria are as follows [48].

3. The evaluation form on the content and the technique of the STEM learning platform using design engineering for reinforcing the computational thinking skills of the undergraduate students was used to check the quality of the STEM learning platform using design engineering for reinforcing the computational thinking skills of the undergraduate students' LMS lesson. It is a 3-level rating scale evaluation form which is categorized into 2 copies as the follows;

Copy 1: The evaluation form on the content of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

Copy 2: The evaluation form on the technique of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.by presenting the evaluation form on the quality of the content to the thesis advisor to validate and adjust for better content. The revised form was then presented to the 5 experts for content validation by considering the Index of Congruence (IOC) and definitions using a 3-level rating scale evaluation form. The score criteria are as follows (Pannee. L, 2015).

4. The lesson plan, academic test, computational thinking skills test (practical test), and online courses used in Digital Media Design and Development were used to explore the efficiency of the STEM learning platform using design engineering for reinforcing the computational thinking skills of the undergraduate students. The study hours including pre-test and post-test were 16 hours: 4 hours per week for 4 weeks. The experiment was started in semester 2 of the academic year 2019.

5. The comparison was conducted to compare the computational thinking skills and academic achievement of the students who studied with the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students. The tools used to collect data were, firstly, one copy of the computational thinking skills evaluation form. This was an authentic assessment with 5-level of scoring criteria (Strobel. J, et al, 2013) (Somsak. P, 2001). Secondly, a multiple-choice objective test was used to test and measure the computational thinking skills of students in the experimental and control groups after studying. The created evaluation form was presented to the thesis advisor for a content and language check. It was then amended for perfection before being presented to the 9 experts for content validity and construct validity assessment by considering the Index of Item - Objective Congruence (IOC) using a 3-level rating scale evaluation form. The result showed that the Item - Objective Congruence (IOC) was bin the range of 0.80-1.00; therefore the computational thinking skills evaluation form can be created. The academic achievement test was presented to the 5 experts for content validity and construct validity assessment by considering the Index of Congruence (IOC) and definitions using a 3-level rating scale evaluation form. The IOC was 0.66-1.00. Consequently, the reviewed academic achievement test was tried out with a large group of students (field tryout) who had the mutual qualifications with the sample group to explore the reliability. Calculated with the KR-20 formula, the reliability was equal to 0.94. The tryout result was used to analyse the level of item difficulty (p) and item discrimination (r) by using the formula of [49]. The item difficulty was equal to 0.48-0.69.

6. One copy of the 5-level Likert scale satisfaction survey (Likert. R, 1967)) was used as a tool to study the satisfaction towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students. It is divided into 2 sections as the follows;

Section 1: General information of the questionnaire respondents (check list form)

Section 2: Survey on the satisfaction towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students. This was a 5-level rating scale survey with 4 evaluation elements consisting of lesson content, teaching media, learning activities, and evaluation.

RESULTS

The results from the suitability evaluation of the STEM learning platform using design engineering, validated by the experts, can be seen in "**Table 1**."

Table 1. *The results from the suitability evaluation of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.*

The documents involved in the suitability evaluation of the platform	The experts (n=9)		Level of suitability
	$\bar{x}$	S	
Lesson plan	4.64	0.49	Highest
STEM learning platform using design engineering for reinforcing computational thinking skills	4.61	0.35	Highest
Computational thinking skills	4.92	0.18	Highest

Table 1 shows that the overall suitability of computational thinking skills is in the highest level ($\bar{x}$ = 4.92, S=0.18), the suitability of the lesson plan is in the highest level ($\bar{x}$ =4.64,S=0.49), and lastly, the STEM learning platform using design engineering is in the highest level ($\bar{x}$=4.561, S=0.35).

2. The experts' conclusion about the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students is shown in **"Figure 1."**

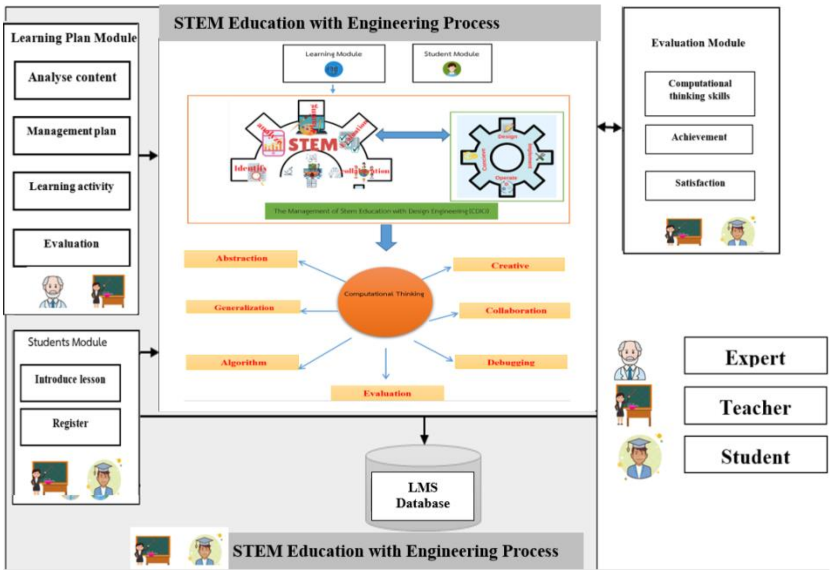

Figure 1. *STEM learning platform using design engineering*

3. The results of the comparison of the LMS lesson's quality of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students are shown in **"Table 2"**, as quality evaluation on the content from the experts.

Table 2. *The results on contents and technique of the evaluation of the LMS lesson quality of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students*

Aspect	$\bar{x}$	S	Result
Content	4.73	0.26	Highest
Technique	4.71	0.25	Highest
Overall	4.72	0.26	Highest

Table 2 demonstrates that the overall results of contents and technique of the evaluation on LMS lesson quality of the STEM learning platform using design engineering for reinforcing computational thinking skills are in the highest level ($\bar{x}$ = 4.73, S = 0.26). By inspecting each aspect, it was found that the quality of the content and technique are in the highest level ($\bar{x}$ = 4.73, S = 0.26) and ($\bar{x}$ = 4.71, S = 0.25) respectively.

4. The results of the students' computational thinking skills between the process and the results of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students shown in **"Table 3"**

Table 3. *The results of data analysis using basic statistics to show mean score ($\bar{x}$) and standard deviation (S) of computational thinking skills and academic achievement.*

Group	n	Full score	Computational thinking skills		Full score	Academic achievement	
			$\bar{x}$	S		$\bar{x}$	S
Experiment	40	50	47.90	1.11	25	23.60	0.77
Control	40	50	31.55	2.55	25	17.65	1.84

Table 3 shows the results of the data analysis using basic statistics to show the mean score ($\bar{x}$) and standard deviation (S) of computational thinking skills and academic achievement. It was found that the computational thinking skills of the students in the experimental group were higher compared to the students in the control group. The mean score of computational thinking skills of students in the experimental group ($\bar{x}$ = 47.90, S = 1.11) was higher than the score of the students in the control group ($\bar{x}$ = 31.55, S = 2.55). The academic achievement score after learning with the platform ($\bar{x}$ = 23.60, S = 0.77) was higher than the score of the students who studied with normal learning methods ($\bar{x}$ = 17.65, S =

1.84). 4. The results of data analysis in order to test the research hypothesis. The researcher tested the basic assumption of multivariate analysis of variance (MANOVA), as shown in "Table 4.

Table 4. *The results of basic assumption testing of multivariate analysis of variance (MANOVA)*

Statistic	Assumption	Data analysis	Test results
Correlation coefficient by Bartlett's Test	Sig < ∝	.00*	Dependent variable does not show causation which causes multicollinearity.
Variance-Covariance Matrix by Box's M Test	Sig > ∝	.06	Variance-Covariance Matrix is equal.
Data distribution by Shapiro-Wilk	Sig > ∝	.05	The data are normally distributed and divided into 2 groups.

*p < 0.05

From Table 4, the overall result of the basic assumption test of multivariate analysis of variance (MANOVA) meets the assumption. Firstly, the test of coefficient correlation using Bartlett's Test found that Sig < ∝. This means that the variable does not show causation which causes multicollinearity. Secondly, the test of variance-covariance matrix by Box's M Test shows that Sig > ∝. This means the variance-covariance matrix is equal. Finally, the test of normal distribution using Shapiro-Wilk found that Sig > ∝. This demonstrates that the data are normally distributed (normality). Therefore, one-way MANOVA is then conducted.

5. The test results of one-way multivariate analysis of variance (one-way MANOVA) between the experimental group and control group are shown in **"Table 5."**

Table 5. *Statistical testing of the differences between the academic achievement and computational thinking skills after studying with the platform of the experimental group and the control group.*

Source of Variance	Statistical Test	Value	F	Sig.
GROUP	Pillai's Trace	.953	789.380	.000
	Wilks' Lambda	.074	789.380	.000
	Hotelling's Trace	20.503	789.380	.000
	Roy's Largest Root	20.503	789.380	.000

Table 5 shows that the academic achievement and computational thinking skill levels after studying with the platforms of the experimental group and the control group are significantly different at the 0.05 significance level. This signifies that at least one teaching method makes a difference in at least one dependent variable of the experimental group and the control group.

Statistical testing of the differences between computational thinking skills after studying with the platforms of the experimental group and the control group is shown in "Table 6."

Table 6 shows that the variance of academic achievement and computational thinking of the experimental group is significantly higher than the group of students who studied with a normal platform at the 0.05 significance level. As the analysis on computational thinking skills is divided for the experimental group and the control group, a paired test is not needed. The analysis results show that the students in the experimental group have higher computational thinking skills compared to the students in the control group.

6. To Study the satisfaction of the students towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students.

The mean $\bar{x}$ and standard deviation (S) of the students' satisfaction towards the STEM learning platform using design engineering for reinforcing the computational thinking skills of the undergraduate students are shown in "Table 7."

Table 7. *Show the satisfaction of the students towards the STEM learning platform*

Aspect	Students (n=40)		Level of satisfaction
	$\bar{x}$	S	
Learning platform	5.00	0.00	Highest
Learning activities	4.88	0.33	Highest
Media and learning sources	4.75	0.43	Highest
Assessment and evaluation	4.93	0.26	Highest
Total	4.89	0.16	Highest

From Table 7, it was found that the students' overall satisfaction towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students was in the highest level ($\bar{x}$ = 5.00, S=0.00). Considering individual criteria, the aspects with the highest level of satisfaction were learning format ($\bar{x}$ = 5.00, S=0.00), assessment and evaluation ($\bar{x}$ = 4.93, S = 0.26), learning activities ($\bar{x}$= 4.88, S = 0.33), and media and learning sources ($\bar{x}$ = 4.75, S = 0.43). It can be concluded from the results that the students' satisfaction towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students was in the highest level.

DISCUSSION AND CONCLUSIONS

It was found that the content validity from the suitability evaluation form of the platform was in the same range of 0.88-1.00. The content validities of the evaluation form, lesson plan, online course, computational thinking exercise, and test is were in the range of 0.88-1.00. The overall results of the quality evaluation of the platform's content and technique were in the highest level ($\bar{x}$ = 4.73, S = 0.26). The analysis of the platform's efficiency was equal to 92.86/91.45. From the comparison of the skills and the achievement of the students' computational thinking skills resulting from the STEM learning platform using design engineering, it was discovered that the academic achievement and computation thinking skills of the students who studied with STEM learning were higher compared to the students who studied with the normal learning platform. It was also found that the students' overall satisfaction towards the platform was in the highest level ($\bar{x}$= 4.89, S = 0.16).

DISCUSSION

The adjustment to the research's objectives and results.

1. The experts' evaluation of the suitability of the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students shows that the quality is in the excellent level ($\bar{x}$ = 4.61, S = 0.35). The researcher studied the pattern which included of 4 main elements: learning plan module, STEM education module, CDIO module, and evaluation module which conformed to (Jantarasena, V., & Asanok, M, 2 0 2 0) by using the theory of STEM education lesson plan development following the conceptual framework of (Lantz. H. B, 2 0 0 9) (National Research Council of the National Academes, 2011) (Whitney, D.R., and D.L. Sabers, 1970) (Institute for the Promotion of Teaching Science and Technology, 2014) (Jumras. I, 2011) (Porntip. S, 2013).
2. The undergraduate students' academic achievement and computational thinking skills after studying with the STEM learning platform using design engineering are significantly higher at the 0.05 significance level which is in line with the hypothesis. The researcher studied computational thinking skills and academic achievement with the created learning platform. It was revealed that the students in the experimental group have significantly higher computational thinking skills and academic achievement compared to the students in the control group at the 0.05 significance level which is in line with the hypothesis due to the researcher's formation of a systematic, high quality, and highly-efficient learning management plan for the pattern. The learning process focused on the practical activities which were able to promote computational thinking skills. The development of the quality lessons allows the students to access the lesson content all the time. The learning management process focuses on practical activities, so it can support computational thinking skills. The development of quality lesson allows students to access to the lesson contents all the time. It also allows them to have interaction with the lessons and their friends in the group. Therefore, the students can have support and reinforcement in the study which is consistent with (Wichai. T, 2015). It gives the platform from the actual trial. The platform is put on trial with students in Thailand and in

high schools in the Lao People's Democratic Republic. The result shows that the students in the experimental group have higher achievement compared to the students in the control group.

3. The students' satisfaction towards the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students was in the highest level ($\bar{x}$=4.89, S=0.16). The experts' evaluation revealed that the quality was in the excellent level, which resulted from the researcher's study of the satisfaction survey following (Aumgri. C & Petsangsri. S, 2019)(Aumgri. C et al, 2018) (Chawalit. C, 2007) (Saroj. S, 1991). Therefore, it makes the evaluation of the satisfaction with the STEM learning platform using design engineering for reinforcing computational thinking skills of the undergraduate students which was developed by the researcher both efficient and implementable.

RECOMMENDATİONS

Recommendations for further benefits.

1. The teacher should understand the evaluation process of computational thinking skills for accurate and appropriate understanding for the benefit of teaching management.
2. The teachers should create understanding in the development process of the STEM learning platform using design engineering for reinforcing the computational thinking skills of the undergraduate students for readiness and appropriateness according to the class teaching management process.
3. The teachers should create understanding in arranging activities and using media of the STEM learning platform using design engineering for reinforcing the computational thinking skills of the undergraduate students for the same understanding. This allows the correct and suitable teaching planning, as well as the preparation in using learning media and the readiness of the equipment.

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Table 6. *Shows the differences in academic achievement and computational thinking skills after studying with the platforms of the experimental group and the control group.*

Source	Dependent Variable	SS	df	MS	F	Sig.	Partial Eta Squared
Corrected Model	Academic achievement	708.050	1	708.050	348.002	.000	.817
	Computational thinking skills	5346.450	1	5346.450	1347.409	.000	.945
Intercept	Academic achievement	34031.250	1	34031.250	16726.134	.000	.995
	Computational thinking skills	126246.050	1	126246.050	31816.452	.000	.998
GROUP	Academic achievement	708.050	1	708.050	348.002	.000	.817
	Computational thinking skills	5346.450	1	5346.450	1347.490	.000	.945
Error	Academic achievement	365.200	78	2.035			
	Computational thinking skills	159.800	78	3.968			
Total	Academic achievement	34898	80				
	Computational thinking skills	131902.000	80				
Corrected Total	Academic achievement	866.750	79				
	Computational thinking skills	5655.950	79				

a R Squared = .947 (Adjusted R Squared = .946
b R Squared = .917 (Adjusted R Squared = .916)