A Proposed Model of a Cloud Based Learning System Using P2P Reverse Engineering Approach To Enhance Computational Thinking of undergraduate students*

การออกแบบระบบการเรียนรู้บนคลาวด์ตามแนวคิดวิศวกรรมผันกลับร่วมด้วยเทคนิคการเรียนรู้แบบเพื่อนช่วยเพื่อนเพื่อส่งเสริมความคิดเชิงประมวลผลสำหรับนักศึกษาระดับปริญญาตรี

Sutiwat Supaluk (สุธิวัชร ศุภลักษณ์)**
Jintavee Khlaisang (จินตวีร์ คล้ายสังข์)***
Noawanit Songkram (เนาวนิตย์ สงคราม)****

Abstract

This research was a part of the Research and Development (R&D). The objective was to design a cloud based learning system using P2P reverse engineering approach to enhance computational thinking of undergraduate students. The article was divided into 2 phases. In Phase 1, the researchers studied authentic situations of cloud based learning systems, P2P reverse engineering processes, and techniques to build up computational thinking for undergraduate students. In Phase 2, the researchers designed and evaluated the instructional

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** Student of the Doctor degree in Educational Communication and Technology, Faculty of Education, Chulalongkorn University.

(นิสิตหลักสูตรครุศาสตรดุษฎีบัณฑิต สาขาวิชาเทคโนโลยีและสื่อสารการศึกษา คณะครุศาสตร์ จุฬาลงกรณ์ มหาวิทยาลัย) e-mail: thearming@gmail.com

*** Major Advisor: Associate Professor Dr. Jintavee Khlaisang, Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University. e-mail: (jintavee.m@g.chula.edu) tel. 02-218-2565

รองศาสตราจารย์ ดร. จินตวีร์ คล้ายสังข์ ภาควิชาเทคโนโลยีและสื่อสารการศึกษา คณะครุศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย) e-mail: (jintavee.m@g.chula.edu)

**** Co-Advisor: Associate Professor Dr.Noawanit , Department of Educational Technology and Communications, Faculty of Education, Chulalongkorn University. e-mail: (noawanit_s@hotmail.com), tel. 02-218-2565

รองศาสตราจารย์ ดร. เนาวนิตย์ สงคราม ,ภาควิชาเทคโนโลยีและสื่อสารการศึกษา คณะครุศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย) e-mail: (noawanit_s@hotmail.com)

model of a cloud based learning system using P2P reverse engineering approach to enhance computational thinking of undergraduate students.

The research methods were also divided into two phases. The first phase involved the design of the model, including information of literature review, undergraduate students' survey, and experts' opinions. The data gathered from this phase were used as guidelines to determine learning processes and components of the model. The research instruments in this phase included a questionnaire for students and an interview for experts. The data was analyzed quantitatively and qualitatively. For quantitative data collection, the instrument was a questionnaire, in which the participants were 685 undergraduate students chosen by stratified multi-stage cluster sampling method. To collect the data in this part, the questionnaire was administered to all participants. Regarding qualitative data collection, the researchers interviewed 10 experts and entrepreneurs chosen by purposive sampling method. The second phase of the research methods involved the model evaluation. The model was developed based on the previous phase, and then evaluated by 7 experts further chosen by purposive sampling technique.

$\bar{X}$The research results were as followed. Firstly, the proposed model had 5 elements, namely Learning System, Cloud-Based Tools, Contents, Role of Instructor and Students, and Evaluation. Secondly, the learning process of P2P reverse engineering approach consisted of 6 steps which are 1) Goal& Group Setting, 2) Planning Together, 3) Choosing a Prototype to be Studied, 4) Co-Analysis, 5) Peer Designing, and 6) Feedback. The overall score of the proposed model's evaluation was at a "Strongly Agree." (= 4.51, S.D.=0.07), and the experts believed that this proposed model can be used in a real context.

Keywords: 1.Cloud-Based Learning 2.Reverse Engineering 3.Peer-To-Peer Technique 4.Computational Thinking 5.Undergraduate students.

บทคัดย่อ

งานวิจัยนี้เป็นส่วนหนึ่งของงานวิจัยและพัฒนา(R&D) โดยมีวัตถุประสงค์เพื่อออกแบบระบบการเรียนรู้บนคลาวด์ตามแนวคิดวิศวกรรมผันกลับร่วมด้วยเทคนิคการเรียนรู้แบบเพื่อนช่วยเพื่อนเพื่อส่งเสริมความคิดเชิงประมวลผลสำหรับนิสิตนักศึกษาปริญญาตรี โดยบทความนี้แบ่งออกเป็น 2 ระยะคือ 1)การศึกษาสถานการณ์ตามสภาพจริงเกี่ยวกับการเรียนรู้บนออนไลน์ การใช้เครื่องมือบนคลาวด์ กระบวนการเรียนรู้วิศวกรรมผันกลับแบบเพื่อนช่วยเพื่อนและวิธีส่งเสริมความคิดเชิงประมวลผลในระดับนิสิตนักศึกษาปริญญาตรี และ2) การออกแบบและประเมินรูปแบบการเรียนการสอนบนระบบการเรียนรู้บนคลาวด์ตามแนวคิดวิศวกรรมผันกลับร่วมด้วยเทคนิคการเรียนรู้แบบเพื่อนช่วยเพื่อนเพื่อส่งเสริมความคิดเชิงประมวลผลสำหรับนิสิตนักศึกษาปริญญาตรี โดยงานวิจัยนี้แบ่งออกเป็น 2 ระยะคือ ระยะแรกเป็นการเก็บข้อมูลเชิงปริมาณโดยเก็บข้อมูลจากนิสิตนักศึกษาระดับปริญญาตรีจำนวน 685 คนทั่วประเทศด้วยวิธีการเลือกกลุ่มตัวอย่างหลายชั้นแบบมีชั้นภูมิ (Stratified Multi-stage Cluster Sampling)และเก็บข้อมูลเชิงคุณภาพโดยสัมภาษณ์ผู้เชี่ยวชาญเฉพาะด้านและผู้ประกอบการ จำนวน 10คนโดยการเลือกแบบเจาะจง(Purposive Sampling) ต่อมาได้ศึกษา วิเคราะห์และสังเคราะห์จากเนื้อหาที่ได้รวบรวม แล้วทำการจัดเรียงแล้วสรุปขั้นตอนของรูปแบบระบบนี้ ต่อมาในเฟสที่สองนำรูปแบบนั้นมาสัมภาษณ์และประเมินผลจากผู้เชี่ยวชาญจำนวน 7 คน แล้วนำมาวิเคราะห์ผล ส่วนที่ 2 นำผลจากส่วนที่หนึ่ง มาร่างต้นแบบของระบบ โดยผลที่ได้ประกอบด้วย 5 องค์ประกอบคือ 1)ระบบการเรียนรู้ 2) เครื่องมือบนคลาวด์ 3) เนื้อหา 4) บทบาทผู้สอนและผู้เรียน และ 5)การประเมินผล นอกจากนี้ยังได้กระบวนการเรียนรู้ในระบบการเรียนรู้บนคลาวด์ฯ อีก 6 ขั้นตอนคือ 1) การเตรียมความพร้อมร่วมกัน 2) การตั้งเป้าหมายและวางแผนร่วมกัน 3) การเลือกต้นแบบสำหรับการเรียนรู้ 4) การวิเคราะห์ 5)การร่วมกันออกแบบชิ้นงาน และ 6)การให้ผลป้อนกลับ แล้วนำไปให้ผู้เชี่ยวชาญด้านเทคโนโลยีการศึกษาจำนวน 7 ท่านในการประเมินรับรองรูปแบบ ผลการประเมินรูปแบบอยู่ในระดับดีมาก ($\overline{X}$= 4.51, S.D.=0.07) และผู้เชี่ยวชาญเชื่อว่ารูปแบบนี้สามารถนำไปใช้ในบริบทจริงได้

คำสำคัญ : การเรียนรู้บนคลาวด์, วิศวกรรมผันกลับ, เทคนิคการเรียนรู้แบบเพื่อนช่วยเพื่อน, ความคิดเชิงประมวลผล, นักศึกษาระดับปริญญาตรี

Introduction

“Thailand 4.0” is a policy vision of Thailand, aiming to change the traditional economy into the innovative one. The ideas are to change commodity products into innovative products, and to move the country forward with technology and creativity in replacement of industrialization (Baxter, 2017). The significant mechanism of this policy is education, which will enhance children and youth to be knowledgeable, capable, and skillful in applying technology into their learning. This can further lead to new innovations. Concerning students’ learning and development, teachers do not only deliver the knowledge content stated in the core curriculum to students, but also help them to possess essential

skills needed for life and careers in the 21st century (Ministry of education, 2017). Nowadays, every career requires multiple skills and technological tools to help facilitate and increase work efficiency. Thus, technological learning is important as it provides students the needed basic skills and helps them develop new innovations.

In Thailand, many educational institutes are improving their educational management and curriculum design to promote thinking skills by integrating science and technology into classrooms. In higher education level, there are determined learning outcome standards for students to be met in order to achieve a bachelor's degree. The standards require that students should be able to use basic programs of information technology and new technological tools efficiently.Students should also be able to apply information technological knowledge in developing new learning media and improving their own learning, communication skills, and presentation skills. Additionally, the standards aim to increase students' understanding of technology-incorporated learning process, and the elements and principles of the information system so that they can use or apply them more efficiently. (The Office of the Higher Education Commission (OHEC), 2017).

In order to develop technology or solve problems using technology, a person needs to thoroughly understand technological principles and processes. The process of analyzing, classifying, and seeking solutions via technology is identified as "Computational Thinking". Computational Thinking is the ability to solve problems, design systems, and understand the systems' behaviors based upon computational concepts. These concepts can explain the capabilities and limitations to evaluate information processed by both humans and machines. This calculation and evaluation process can solve any problems by itself, in which no humans can do it alone. It can process a large amount of complicated data, and create an intelligent system similar to humans' thoughts and behaviors. (Wing, 2006; Denning, 2009; Lu and Fletcher, 2009; Barr and Stephenson, 2011; Czerkawski and Xu, 2012; Microsoft , 2015; Kalelioglu, Gülbahar, &KUKUL, 2016) Because basic technological systems come from computer's data processing, we can use computer to develop new innovations necessary for everyday life if understanding its principles. Moreover, we can apply it in solving several problems, from easy ones to sophisticated ones, which even humans cannot do it effectively.

Computational thinking is an advanced skill. In order to promote high-level thinking skills, carefully-designed lesson plans are necessary. Ubonwan Songserm and Chairat Tosola (2017) mentioned in their study that the teaching design, which helps promote high-level thinking skills, requires active learning process to help students learn and understand the contents genuinely.

The designed activities must encourage students to be able to learn both individually and collaboratively, and motivate them to study, gather information, and seek for solutions or initiate new works. A good teaching design should allow students to know their study progress of each lesson, so that they can keep track of their learning and reach their study goals.Learning complicated subjects is difficult to do it alone; therefore, cooperative learning or group learning is needed. While learning, each group member with different abilities can share and exchange their knowledge, help out one another, and learn to be responsible for the assignments together. This type of learning can be identified as Peer to Peer learning (P2P) in this research study. With this learning method, students can use their personal abilities and potentials to solve problems successfully and collaboratively (Siwanit Auttawutikul, 2008; Cherdwong Hongsrichinda, 2014)

In the society of collaborative learning, integration of various disciplines are unavoidable, especially in the industrial society that Thailand is trying to be one of the leaders. However, it is not easy to establish new industries. In order to do so, we need numerous resources and a huge amount of money within limited time. Therefore, new industries are almost impossible to happen. Currently, there is a learning process which is very popular in the industrial society. This learning process is known as Reverse Engineering Process. Reverse Engineering Process is the process of analyzing or breaking down information about the designs of everything built by human beings, and then re-designing or re-building the system or machine, or trying to repair or improve it. This process is wildly used in the electronic, software, mechanic, and automotive industries. The advantages of this process is that it can save time and money, and help identify the weaknesses of the designs for better improvements. (Ali, 2005; Eilam, 2005; Raja & Fernandes, 2008; Yea et al, 2008).

Many federal and private organizations are now applying technology into their work and study. With technology, they can learn, communicate, exchange ideas, create new knowledge, or work anytime anywhere. One of the technological tools that support these features is Cloud Technology. Cloud Technology is wildly used and very popular nowadays (Kulachai Kultawanich, 2005; Naik &Madhavi, 2015; Electronic Government Agency, 2017; Johnson, L. D., 2017).

With the reasons stated above, the researchers gathered the information about technological learning and how to promote computational thinking. The researchers, then, designed and evaluated the prototype prior to the actual development.

Research Objectives

The purposes of this study were:

1) To study authentic situations of cloud based learning systems, reverse engineering process with P2P technique, and computational thinking of undergraduate students.

2) To design and evaluate the instructional model of a cloud based learning using P2P reverse engineering approach to enhance computational thinking of undergraduate students.

Scope of the Study

Population and Samples

This research was divided into 2 phases which are:

(1) The study of literature review and related studies, and the investigation of undergraduate students' survey and experts' opinions;

(2) The evaluation of the proposed model.

Phase 1:

1.1) Undergraduate Students Population: The population were 1,225,873 undergraduate students under the Office of the Permanent Secretary, Ministry of Education in 2017.

Samples: The samples were 685 undergraduate students under the Office of the Permanent Secretary, Ministry of Education in 2017. The samples were chosen by stratified multi-stage cluster sampling technique. The Krejcie & Morgan formula was used for calculation and the error was found at 0.5 (Robert V. Krejcie, and Daryle W. Morgan, 1970.

1.2) Experts:

Population: The population were experts in the areas of cloud based learning, reverse engineering approach, peer assisted learning technique and computational thinking.

Samples: 10 Experts were chosen by purposive sampling of individuals with more than 3 years of experience in relevant fields.

Phase 2:

Population: The population were experts in the areas of cloud based learning, P2P reverse engineering approach and computational thinking.

Samples: 7 experts were chosen by purposive sampling of individuals with more than 5 years of experience in relevant fields.

Duration of research

From Academic Year 2016 to 2018.

Methodology

The research methodology and research instruments were also divided into 2 phases which are:

(1) The study of literature review and related studies, and the investigation of undergraduate students' survey and experts' opinions. The questionnaires and interview form were approved by 3 experts from educational technology and communication field to gain the content validity, using the index of item-objective congruence.

(2) The evaluation of the proposed model. The form of questions was approved by 3 experts from the area of educational technology and communication to gain the content validity, using the index of item-objective congruence. The questions were open–ended questions and consisted of 3 different sections; 1) personal information of the interviewees, 2) the questions about the model, and 3) the suggestions of the interviewees.

Phase 1:

In this phase, the researchers studied theories, principles and researches related to cloud based learning, P2P reverse engineering approach, and computational thinking. The information gathered from this studying were used as guidelines to determine learning processes and components of the model. Then, the researchers designed a model of cloud based learning system to enhance computational thinking based on the analysis of the studied information and the data collected online via the survey of 685 undergraduate students. After that, the in-depth interviews were conducted with experts in order to receive their opinions towards the model.

Phase 2:

After gathering all of information and modifying the model, the researchers created the tools for evaluating the appropriateness of the model system, and presented it to seven educational technology experts. These experts evaluated the model by using a 5-point Likert scale evaluation form, in which the 5 scales consisted of strongly agree, agree, undecided, disagree, and strongly disagree. The criteria used for selecting the 7 experts in this part were as followed: (1) the experts must have more than 5 years of experiences in the educational technological fields of cloud based learning, P2P reverse engineering approach, or

computational thinking, (2) the experts must have a related work in educational technology field, and (3) the experts must have experiences in classroom designing or teaching with undergraduate students.

Results

Phase 1: Related theories and studies, undergraduate students' survey, and experts' opinion

Undergraduate Students' Background Information

The results of data analysis regarding the background information of the undergraduate students revealed that there are more students from the faculty of humanities and social sciences than the students from the faculty of science and technology, converting into the percentages of 64.8 and 35.2 respectively. The students were further classified into 6 groups according to the regions they originally come from. The analyzed data showed that (1) 38.2 percent of all the students are from Central Thailand, (2) 21.9 percent are from Northern Region, (3) 12.8 percent are from Northeastern Region, (4) 16.4 percent are from Southern Region, (5) 10.1 percent are from Eastern Region, and (6) 0.6 percent are from Western Region.

Peer to Peer Learning Technique

The analysis results of Peer to Peer Learning Technique indicated that the percentage of students who preferred both individual and group learning is 70.4, whilst the percentages of the ones who preferred only group learning, and only individual learning are 19.8 and 9.8 respectively. Among all students, 80.8 percent of them recommended that the greatest benefit of peer to peer learning technique is that it promotes collaborative learning in which one can help out one another. The second best benefit which 78.5 of them agreed is that it helps easing communications and interactions while learning. 75.4 percent of the students thought that peer to peer learning creates comfortable learning atmosphere in class, and 75 percent of them mentioned that it helps increasing their motivations and positive learning attitudes.

Reverse Engineering Approach

From the data analysis of the learning process incorporated with reverse engineering approach, it revealed that 81.7 percent of undergraduate students had experience in choosing a prototype and then re-creating the exact same model. 62.3 percent of students stated they need to choose the prototype by themselves in order to get the best or most suitable one.

Among all chosen prototypes, 61.2 percent were well-known by all students and 38.2 percent were chosen by the instructor. The data also pointed out that 60.7 percent of the students used to have experiences in separating elements of prototypes and studying about the prototypes' structures, methods, and systems. Concerning the advantages of reverse engineering approach, 75 percent of them agreed that one advantage of integrating reverse engineering approach into learning or working is that it effectively helps them understand the contents and methods. 68 percent of students mentioned that the approach is practical. 63.2 percent of them thought that it helps saving time, and 52 percent said that it helps saving money or expenses.

Computational Thinking

Regarding computational thinking, most students understood that computational thinking is the skill of analyzing information and solving problems, converting into the percentage of 53.9. However, 20.3 percent of students rather considered computational thinking as computer thinking and the process of thinking in orders. 10 percent of them reviewed it as the ability of data management, and 6.2 percent of them evaluated it as a logical thinking skill. Students also pointed out that there are four learning methods that support computational thinking the most, which are system designing practice(98.7%), flowchart and mind mapping (75%), simulated problem solving situations(63%), and collaborative group learning(55.4%). They also pointed out that four technological tools that help support computational thinking skill the most are computers, smartphones and tablets (53.2%), cloud computing technology which support collaborative learning (52.6%), data analyzing tools (50.4), and digital game designing tools (48.8) respectively.

Cloud based learning system

According to the collected data, we found out that 93.1 percent of the undergraduate students are familiar with online learning systems. 96.3 of them use cloud computing for group learning and working via accounts of Facebook, which is the most popular and often used application for students. The cloud tools that students use the most often are Google Drive (93%), Google Doc (56.4%), Google Sheets (46.4%), and Google Slides (38.2%), respectively. The data indicated that students used Google Drive as a cloud computing tool the most often, and they can use it so effectively that 40.6% of them are at the "High" level and 13% of them are at the "Very High" level.

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3.2 Phase 2: Design and Evaluation of the Proposed Model

From the literature review, related studies, and experts' opinions, the researchers came up with the conclusion that the model consisted of five core components: 1) Learning System, 2) Contents, 3) Role, 4) Cloud Based Tools, and 5) Evaluation. The relationship of the five core components was as followed:

Regarding the first component or learning system, the instructor delivered classroom lessons in the way that the students could effectively process their learning step by step. Importantly, the contents of the system, which is the second core component, must have indicators that align with learning outcome standards in cognitive, numerical, communicative, and information technological skills. Then, the third component or roles of instructor and students needed to be specified so that students could learn efficiently and cooperatively. The instructor's role in this model was a facilitator. During cooperative learning via the system, students could use cloud-based tools designed by the instructor to promote both synchronous and asynchronous learning. Finally, evaluation or the fifth core component was necessary. To assure that the students succeeded in their learning according to the assigned criteria, the instructor's evaluation and students' self-evaluation were needed.

Further information and experts' suggestions of the model's five core elements were shown as in Table 1

Table 1. Elements of the model

Elements	Description & Commendation
1) Learning System:	The learning system or the instructional design for this model is based on system approach, which includes the modules of content management, membership, activities, knowledge supports, and evaluation while and after learning. This learning system promotes activities and procedures of learner-centered approach, which is suitable for students with different learning preferences and collaborative learning. Most experts agreed with this learning system; however, they suggested that the researchers should further improve the system to be easier, speedier, more convenient, and more flexible for users to implement.

2) Contents:	The contents must have indicators that align with learning outcome standards in cognitive, numerical, communicative, and information technological skills. Most experts agreed with this model's contents in which technology was integrated into learning, such as designing games, robot programming, etc. However, the experts advised that the researchers should clearly specify the learning purposes, the scope and natures of contents, and the evaluation methods of each lesson.
3) Roles:	The roles of the learning system can be divided as followed: **The roles of the instructor:** The instructor clearly determines teaching procedures, and takes the role as a facilitator or supporter when students need help. The instructor motivates, reinforces, and stimulates students to initiate thinking by asking questions. Finally, the instructor evaluates students' learning. **The roles of the students:** Students communicate, debate, give advices and help out one another within their group. They encourage interactions among group members. Each student needs to possess the required knowledge, communication skills, and relationship building skills. They should understand individual needs of each group member in order to support one another. This will finally help them develop themselves in many ways and increase their potentials. The experts agreed with the determined roles of both the instructor and students. They further recommended that the researchers should also clearly identify the roles of both in each learning procedure.
4) Cloud Based Tools	The researchers have categorized cloud based tools for learning system into six categories as follows: (1) Content creation tools, such as Google Document, (2) Data gathering tools, such as Google Drive, and Google Search Engine, (3) Collaborative tools, such as Linoit, Google Drawing, and Mindmeister (4) Presentation tools, such as Google Slide, and Linoit, and (5) Communication Tools, such as Facebook, and Line (6) Learning Supporting Tools, such as Code.org, Microbit, and Lightbot game. Most experts agreed with the cloud based tools used for this study. Anyway, they advised that the researchers should explain more about the

	factors and criteria used for selecting the tools that are suitable for students.
5) Evaluation:	There are two assessment types in this model: (1) Formative Assessment, which will be conducted to assess learners during the learning process by using computational thinking rubric. (2) Summative assessment, which will be conducted by using computational thinking test and self-assessment before and after using the model. Most experts approved these evaluation methods. However, they suggested further that the researchers should ensure that the evaluation methods are valid, reliable, and efficient.

From the literature review, related studies, and experts' opinions, the researchers have studied about the learning process of reverse engineering and peer-to-peer learning techniques. Then, the researchers integrated the knowledge into the model and created new procedures. The results also indicated that the learning process of the model consisted of six steps which were 1) Goal & Group Setting, 2) Planning together, 3) Choosing a Prototype to be Studied, 4) Co-Analysis, 5) Peer-Designing, and 6) Feedback.

Further information and experts' suggestions of all 6 steps were shown in Table 2.

Table 2. Learning process of the model.

Learning procedures	Descriptions
1. Goal& Group Setting:	The instructor divided students into groups, and helped each group set up their learning goals, conditions of learning, agreements, while-activities evaluation methods, and grading criteria.
2. Planning together:	Students in each group planned their learning procedures. They searched for needed information, gathered the information, and then determined the desired outcomes or the contents they wanted to study further.
3. Choosing a prototype to be studied :	Each group chose a prototype to be studied, and then tried to reach the determined learning goals. The instructor assisted students in choosing a prototype and reaching the goals.

4. Co-Analysis:	Students in each group examined and analyzed the chosen prototype step by step. First, students breaking down the main elements of the prototype into sub-elements. Then, students carefully analyzed each element and categorized them into groups. Finally, students looked for the abstraction of the prototype.
5. Peer-Designing:	Based on all the information gathered, students in each group designed the structures of the prototype by using thinking-enhancing tools like flowchart, concept map, etc.
6. Feedback:	Students from each group presented their work, and then exchanged their opinions via communication tools. The instructor gave students reflections, feedbacks and advices during the activity.

According to the literature review and related studies, the standards of the computational thinking for education (Google Education, 2015) as research framework consist of 4 elements as shown in Table 3.

Table 3. Elements of computational thinking in the model.

Elements of CT	Description
1. Decomposition:	Breaking down data, processes, or complex problems into smaller, manageable parts.
2. Pattern Recognition	Observing patterns, identifying similar problems, and regularities in data.
3. Abstraction:	Identifying the general principles that generate these patterns or focusing only on the details
4. Algorithm Design:	that are important, whilst irrelevant information is ignored

The evaluation scores of the proposed model from seven educational technology experts were summarized in Table 4.

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Table 4. The evaluation of the design appropriateness of a cloud based learning using P2P reverse engineering approach to enhance computational thinking of undergraduate students.

Evaluation Criteria	Results		Interpretation
	$\bar{X}$	S.D.	
1. The elements of the model were related a Cloud-Based Learning using P2P Reverse Engineering Approach	4.46	0.19	Agree
2. The learning process of this model	4.60	0.12	Strongly Agree
3. The supporting cloud based tools of this model	4.45	0.06	Agree
4. The learning assessment of this model	4.43	0.00	Agree
5. The proposed model to be developed was suitable for Computational Thinking	4.57	0.53	Strongly Agree
6. The proposed model showed the possibility for researchers to develop it in the practical system.	4.57	0.53	Strongly Agree
Summary	4.51	0.07	Strongly Agree

Note: 4.5 - 5.0 = Strongly Agree, 3.5 - 4.49 = Agree, 2.5 - 3.49 = Undecided, 1.5 - 2.49 = Disagree, 1.0 - 1.49 = Strongly Disagree

From Table 4, the proposed model overall score was at a “Strongly Agree,” level. The model procedures indicated that most of the experts strongly agreed with using P2P reverse engineering approach to enhance computational thinking, and the experts believed that this proposed model can be used in a real context. The illustration of the proposed model was shown in Figure 1.

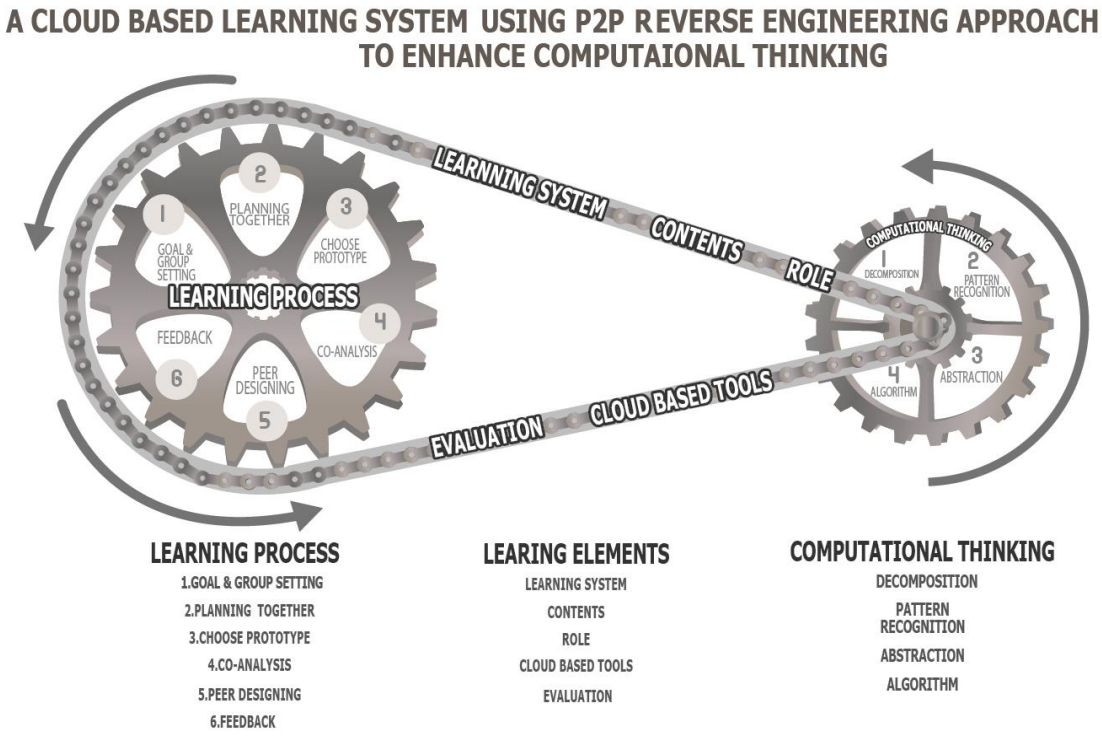

Figure 1 The Illustration of the proposed model

Discussion

The complete elements and the learning process of this model were from analyzing and synthesizing theories and approaches of cloud based learning system, reverse engineering, peer to peer learning technique, and computational thinking. Then, the researcher created the elements of the model according to Kulachai Kultawanich, Prakob Koraneekij, and JaitipNa-Songkhla (2015). The results showed that there were five core components needed in order to develop the model, which were 1) learning system, 2) contents, 3) role, 4) cloud based tools, and 5) evaluation. The learning process of the model consisted of six steps, which were 1) Group & Group Setting, 2) Planning Together, 3) Choosing a Prototype to be Studied, 4) Co-Analysis, 5) Peer-Designing, and 6) Feedback, respectively.

Regarding the model's elements, there were discussions about each element stated as follows:

1) The learning system of this model included the modules of content management, membership, activities, knowledge supports, and evaluation while and after learning. This learning system promoted activities and procedures of learner-centered approach, which was suitable for students with different learning preferences and collaborative learning. This agreed with the study of Jintavee Monsakul (2007) who reviewed from the faculty

perspectives about learning management systems in higher education levels. The results indicated that the modules of the system promoted collaborative learning between the instructors and the students.

2) Contents must have indicators that align with learning outcome standards in cognitive, numerical, communicative, and information technological skills due to the core curriculum of Thailand (OHEC, 2017). The examples of appropriate contents are designing games, robot programming, etc.

3) Role in this model consisted of 2 categories: instructor's role and students' role. The instructor' role was as a facilitator or a supporter to students. The instructor motivates, reinforces, and stimulates students to initiate thinking by asking questions. Then, the instructor evaluates students' learning. The students' role was to learn, communicate, debate, give advices and help out one another within their group.

4) Cloud based tools can be used to support student engagement and to enhance the collaborative learning. According to Behrend, T. S., Wiebe, E. N., London, J. E. and Johnson, E. C. (2011) who mentioned about cloud computing adoption and usage in community colleges, the researchers have categorized cloud based tools for learning system into six categories. The six categories were (1) Content creation tools, (2) Data gathering tools, (3) Collaborative tools, (4) Presentation tools, (5) Communication Tools, and (6) Learning Supporting Tools, respectively.

5) The last model's element is evaluation. This element is for showing the results of learning. According to Rattama Rattanawongsa, Prakob Koraneekij, and Poonarat Pichayapaiboon (2017), evaluation consisted of two assessment types: formative assessment and summative assessment. Both types are necessary for evaluating students' learning outcome are available on online learning system.

Both of the model's elements and learning process scores were at the "strongly-agree" level because of the following reasons:

Due to the study of authentic situations of cloud based learning system, P2P reverse engineering process, and computational thinking, the researchers discovered that computational thinking (CT) is a necessary skill for not only computer scientists, but also everybody. Computational thinking teaches people to think critically, and seek for solutions by using system concepts. This agreed with the study of James J. Lu and George H.L. Fletcher (2009), which argued that to successfully broaden awareness of the depth and the breadth of computer science, efforts must be made to lay the foundations of CT, long before students

experience their first programming language. Consequently, teachers should create more of the instructional designs that enhance this advanced skill, which will need active learning process to encourage students to study and seek for solutions, or initiate new works. This agreed with the study of Ubonwan Songserm and Chairat Tosola (2017), which stated that active learning instruction is necessary for the development of higher order thinking skills.

In this study, the researchers applied reverse engineering process with P2P technique into teaching, which helps promote the students' skills of analytical thinking, problem solving, and work initiation. Reverse engineering (RE) is a new concept that denotes the process of generating engineering design data from existing components. Currently, reverse engineering is having applications in the fields of software engineering, automotive, consumer products, microchips, electronics, and mechanical designs. This agreed with the study of B. Vijaya Ramnath et al. (2018), which revealed that there was the implementation of reverse engineering in crankshaft manufacturing industry. The utilization of P2P technique into teaching can help promote collaborative learning and enhance computational thinking skill. This statement is in accordance with the study of Xabier Basogain, Miguel Angel Olabe, Juan Carlos Olabe, and Mauricio Javier Rico (2018), which suggested that blended learning developed students' computational thinking skills. Additionally, Sitthichai Laisema (2018) studied that the development of collaborative blended learning activity on mobile learning could enhance undergraduate students' collaboration skills. The results indicated that the students' learning outcome was at a highest level.

One of the technological tools that help enhancing collaborative learning is cloud technology. Cloud computing is a technological tool that allows users to access hardware, software applications, storage, and computing processes directly from a website. One of the benefits of cloud computing technology is that it is available online in the form of applications. Besides, it is flexible for users to create learning environments. It also provides scalability and supports intensive computing activities. This relates to the study of Jose A. Gonzalez-Martínez, Miguel L. Bote-Lorenzo, Eduardo Gomez-Sanchez, and Rafael Cano-Parra(2015), who surveyed the state of the art on the use and research of cloud computing in education following a systematic methodology.

The evaluation results of a cloud based learning using reverse engineering approach and P2P technique model were related to Kulachai Kultawanich's research, which stated that cloud based virtual classroom enhances information literacy for undergraduate students. Another research written by LeAnne D. Johnson (2017) states that the cloud computing tools enhance team-based problem solving skills for challenging behaviors and increases the efficiency and effectiveness of students' learning.

Research suggestions

In order to apply this learning model, educational institution should prepare infrastructures for network systems and internet access, as it is an essential part for the learning system and cloud technology. Importantly, the chosen prototype also needs to work well with the assigned time frames. Last but not least, further studies are required for validating the model with different groups of teachers or learners. This will significantly lead to the development of the model, helping it to be suitable for other educational levels as well.

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