Integrating Situation-Based and Simulation-Based Approaches for Teaching Computer Network Design by the Process Mining Technique: Fuzzy Model

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Abstract
The objectives of this study were: (1) to measure learning achievement after learning process by using Active Learning and E-contingent Learning for teaching computer network design, (2) to study students' satisfaction on learning by such both teaching models, and (3) to analyze behaviors of students during learning by the Process Mining Technique (PMT). The study was done on the sampling group of 22 third-year students, majoring Computer Business at the Faculty of Business Administration, Thonburi University. From the study, it could show the Cronbach's alpha reliability of questionnaires at .85. The data were statistically analyzed for mean, standard deviation, and t-test. The research results revealed as follows: (1) After learning by using such 2 Learning processes for teaching computer network design, the mean score of post-test was statistically significantly higher than that of the pre-test. (2) Students rated their satisfaction on learning by this teaching model at a higher level. (3) Through Process Mining Technique with Fuzzy model, it supported learners with high achievement Participated in activities at 26.80% while moderate one at 58.63 % and the low one at 14.57 %. The high and moderate ones had repeated learning behavior to case study practices up to 3,424 times out of 4,008, at 85.4 %. Such groups took continuous training in the practices at an average of 9.7 hours. Applying active learning, E-contingent learning management models, and Process Mining Technique could improve learners. Instructors could clearly understand learners' behavior and suitably adjust instructing activities to better fit the learners' behavior.
Keywords: Integrating Situation-based, Simulation-based Approaches, Simulation-game, Process Mining Technique, Fuzzy model

Introduction
Students in the 21st Century are different from the students in the past because of the complexity of society and the progress of science and technology. The learning outcomes of these students must include knowledge, ability, and skill to apply technology and to be able to use their critical thinking skills, planning ability, systematical thinking, and living in society happily with others (BattellefoKids, 2019). The learning outcomes of these students may result from employing active learning and E-contingent learning. The researchers, as

well as teachers, adapt or change their teaching techniques according to the analysis results of learning behaviors. Teachers could help, facilitate, and motivate particular students according to their needs or problems occurring during their activities. This is because each student faces different situations, so the teachers need to select and use different methods to solve the problems. One of practical teaching technique should be active learning.

Active learning is a form of learning which the attempt of teaching is to encourage students to participate in the learning process (Bonwell & Eison, 1991). Students are engaged with teaching materials. They participate in the class and collaborate with each other through reading, writing, talking, and listening. They reflect their learning. In an active learning environment, learners are immersed in experiences within which they engage in meaning-making inquiry, action, imagination, invention, interaction, hypothecation, and personal reflection (Cranton, 2012). In short, students use high order thinking skills because they have to read, write, talk, discuss, collaborate, practice, and reflect their learning, so that they gain their knowledge and learn how to learn by themselves. Level of learning and memory of learners by Active learning could be shown in Figure 1.

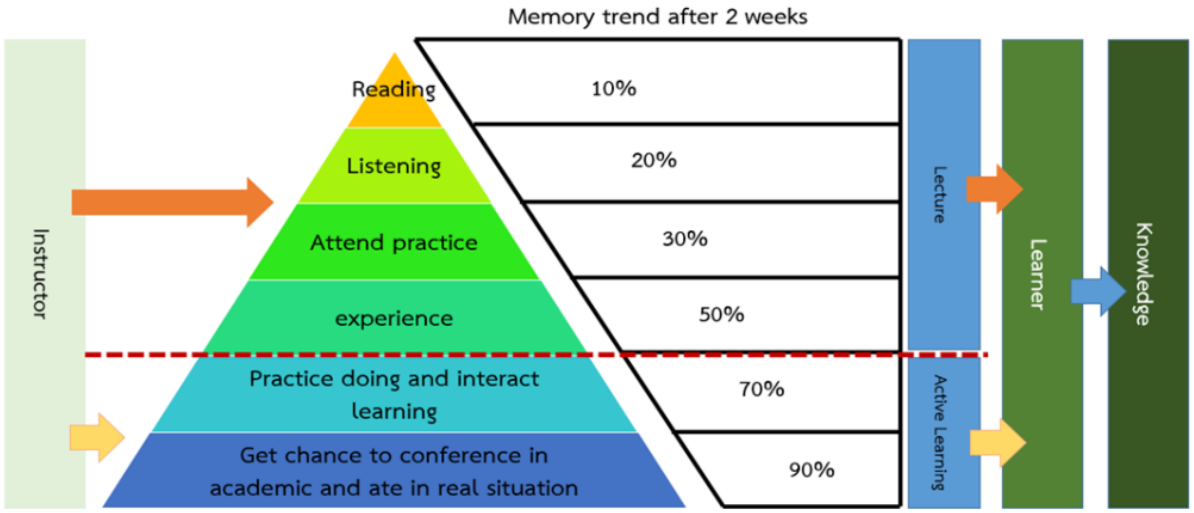


Figure 1 Level of learning and memory of learners by Active learning
Source: Sooksai (2017)

Figure 1 illustrates that levels of learning and memory of learners who learn by active learning increase 70% because they play their roles in the inquiry of their knowledge and have interactivity in learning. As a result, they can present their knowledge and learn in the simulation which allows them to practice in real situations and connect to other situations. This enables them to increase their learning 90% because learners perform their tasks and think what and why they do in the active learning process (Bonwell & Eison, 1991). The underlying assumption in organizing the activities by using active learning is that learning is the nature of human and individual learning differently (Meyers & Jones, 1993). Roles of learners change from receivers to co-creators because they participate in the learning process (Felder & Brent, 1996).

E-contingent learning refers to learning and teaching by using a case study for students, so that they have opportunities to practice their professional works. Moreover, students have chances to think critically, to solve the specific problems when they learn by this case study. In the case study, teachers can design situations unlimitedly (Sooksai, 2016). Information System Development for Contingent Instruction on logistics (ISD-CIL) model (Sooksai, 2016) could be shown in Figure 2.

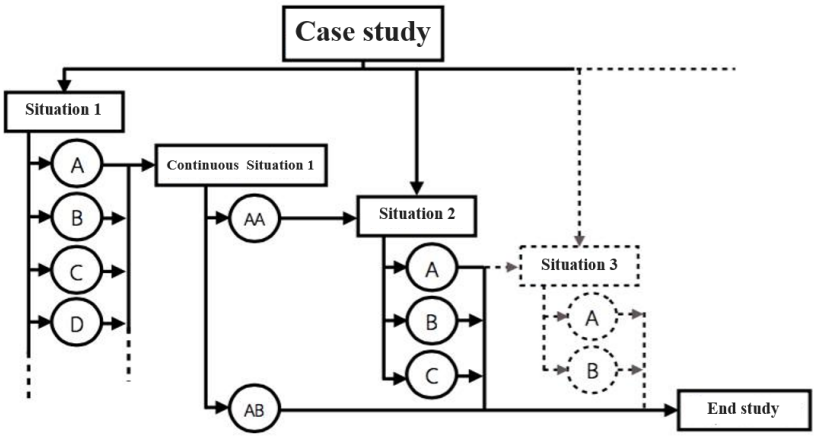


Figure 2 Information System Development for Contingent Instruction on logistics (ISD-CIL) model
Source: Sooksai (2016)

The major situations containing many sub- situations and problems in each situation can be solved by many techniques. As a result, students have to choose the most appropriate technique based on the fact of the information about each situation and decision making. The system must be designed and developed in co-responded to an environment and situation which are crucial and reasonable. The correct answer may be more than one because every student can solve the problem altogether. However, when students choose one a technique to solve the problem, there will affect to other situations. Finally, students can learn from this simulation without the lecture.
Process mining (van der Aalst, 2011) is a new technology and use for analyzing the value of data. These data are recorded while the events occurring. The purposes of Process mining are to discover, to check conformance, and to enhance the process. See Figure 3. Getting the data (van der Aalst, 2011)

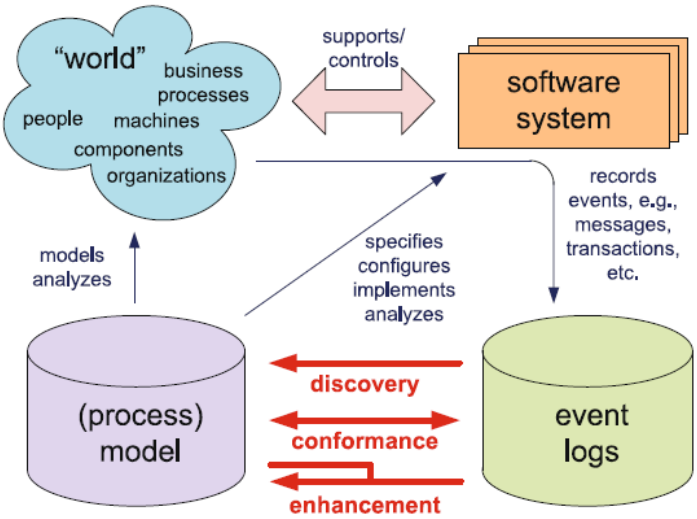


Figure 3 Getting the data
Source: van der Aalst (2011)

Users can see the results of Process mining and the relationship of each activity deeply from the beginning to the end of the process. Thus, Process mining has been used widely in industry, research, and development. (Premchaiswadi, 2015; Nammakhunt, Romsaiyud, Porouhan, & Premchaiswadi, 2012)

Therefore, this paper designed activities for students based on active learning and E-contingent learning approaches. The objectives this study were: (1) to measure learning achievement after learning by using active learning and E-contingent learning for teaching computer network design, (2) to study students' satisfaction on learning by this teaching model and (3) To study the behavior of students by the PMT.

Research Method

Population

The participants in this study were 22 third-year students, majoring Computer Business at the Faculty of Business Administration, Thonburi University, who registered to the course of 252201 Computer Networks. They were part-time students; they studied this program only during the weekend. All of them worked during the weekdays and all of them were recruited to do the experiment in this study.

Research Tools

Research tools included two types: experimental tools and data collecting or statistical tools. The experimental tools comprised:- Microsoft Forms from Office 365 was used for displaying questions and recording students' answers, Mobile phone was used to read QR code, QR Code Reader was used as a tool to read the questions and to record the time spent in each question, Simulation Cisco Packet Tracer was used for practicing computer network design and to solve the problems. Other utilizing tools were the Internet, A4 paper, and a printer. The statistical tools comprised:- Pre-test, post-test, and satisfaction questionnaires (5-point rating scale in which 1 scale indicates lowest satisfactory and 5 scales indicates the highest satisfactory), Disco program was used to analyze behaviors of students while learning by the Process Mining technique. Data of learners such as events of log-in, reading questions, and work submission were recorded and displayed their learning behavior as workflow, frequency, and Mean Duration Performance. Thus, teachers adapted or changed their teaching techniques according to the analysis results of learning behaviors.

Simulation-game Design:

The objectives of the simulation-game are: (1) to analyze and synthesize the computer network systematically and (2) to solve problems of computer networks and design the new one.

Before playing the simulation-game: the lecturer set up the computer network system for each student to simulate, so it served as a case study for one student. Each network included a situation and time recorder. Students were asked to scan their QR code before they can read the situation, related questions, and solve problems of their network. Then they answered questions in the form provided.

Playing the simulation-game: First, the lecturer told the objectives of the simulation-game and asked students to play the game voluntarily. Then he asked students to do the pre-test and collected the test back. He explained the theory of the computer network system and how to play the game (See details in the next section.). Students were assigned to play the game for one hour and then submitted their answers. After finishing this network simulation, students did post-test and answered satisfaction questionnaires.

How to Play the Game:

1) The students start the game by using the mobile phone to read the QR code to record the starting time. After that, students study the situation and questions of each case study.
2) Then students design the computer network step by step by using Simulation Cisco Packet Tracer program. The network design has to respond to all questions stated in each case study.
3) While playing the game, students are allowed to talk and discuss with other students but they must complete their game by themselves.

4) After students complete their case study, the lecturer randomly selects each student to present their experience and share the solution.
5) The lecturer and students conclude the problem and solution and learning experiences together.
The teacher plays roles as an observer and facilitator while students are playing the games.

Data Analysis

Data were analyzed by percentage, average score, standard deviation, t-test, and Process Mining Technique.

Results

From the study, it could show the related results as follows;

1**)** Learning achievement after learning by using active learning and E-contingent learning for teaching computer network design: This section compares the pre-test and post-test mean scores of After learning by using active learning and E-contingent learning for teaching computer network design to determine whether there were significant differences in the rates of students learning earning the achievement or not**.** The sampling group would be composed of 22 part-time students to be studied for the statistical measurement of the t-test**.** Practically, the mean score of post-test was statistically significantly higher than that of the pre-test**.** The standard deviation of post-test spread out more than that of the pre-test**.** The result of the Comparing mean score before and after the study by using active learning and E-contingent learning for teaching computer network design could be shown in Table 1**.**

Table 1 Comparing mean score before and after the study by using active learning and E-contingent learning for teaching computer network design

Tests	M	SD	df	t	p
Pre-test	18.863	5.531	21	7.294	.000
Post-test	43.409	16.299			

2**)** Students**'** satisfaction after learning by using active learning and E-contingent learning for teaching computer network design: The 22 sampling students were asked to do the satisfaction questionnaire in order to investigate their satisfaction after learning by using active learning and E-contingent learning models for teaching computer network design**.** The Scale interpretation was shown in Table 2**.**

Table 2 Scale interpretation

Level	Mean	Interpretation
5	4.50 - 5.00	highest
4	3.50 - 4.49	higher
3	2.50 - 3.49	middle
2	1.50 - 2.49	lower
1	1.00 - 1.49	lowest

The results could display that the students rated their satisfaction after learning by using active learning and E-contingent learning for teaching computer network design at a high level (M = 3.905-4.286). The standard deviation ranged .539-.740. The Cronbach alpha reliability coefficient of the satisfaction questionnaire was 0.85. The results of Satisfaction levels of students after learning by using active learning and E-contingent learning for teaching computer network design could be shown in Table 3.

Table 3 Satisfaction levels of students after learning by using active learning and E-contingent learning for teaching computer network design

Satisfaction levels of students in three aspects.	**M**	**SD**
Teacher performance	**4.075**	**0.641**
1. The teacher clearly stated the purpose and learning syllabus	4.048	0.740
2. Teacher punctuality (not more than 15 minutes late)	4.143	0.655
3. The teacher had the ability to control the class	4.286	0.717
4. The teacher had the knowledge and experience in teaching	4.190	0.602
5. The teacher followed the course syllabus	4.143	0.655
6. Teacher completed the essential materials on the course syllabus	4.048	0.590
7. The teacher arranged the lesson clearly	4.000	0.548
8. The teacher gave the clear examples which relevant to the lecture	4.238	0.625
9. The teacher used teaching techniques and methods to create the study ambiance	3.905	0.625
10. Teacher summarized the lesson well	3.952	0.669
11. The teacher answered the questions clearly and precisely	4.000	0.632
12. The teacher advised or introduced ~~for~~ outside learning materials	3.952	0.669
Learners' Centre facilitation	**4.107**	**0.655**
1. The teacher allowed students to participate in the activity which relates to the study	4.190	0.602
2. The teacher encouraged students to discuss and summarize.	4.238	0.625
3. The teacher used a variety of learning activities to encourage the mutual study	4.048	0.669
4. Encourage students to give their opinions	3.952	0.740
Teaching Materials and Games:-	**4.000**	**0.643**
1. Teaching materials and games included the books or documents which relevant to the games	4.143	0.655
2. Game/media/case study helped the understanding	3.952	0.740
3. Variety of tools and media were suitable for the lessons	3.905	0.539

3) Results of Process mining: For the study through Process mining, it could show the results related to the processed activities. The sample data of learner behavior during activities could be shown in Figure 4.

A	D	F	G	I	J	K	L
StudentID	DateEvent	Component	Event_Context	IPAddress	Part1	Part2	Sum2Part
5901102057001	04/11/2017 16:09:00	URL	URL: วิดีโอขั้นตอนการติดตั้งและเลือกอุปกรณ์	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:09:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:09:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:09:00	ระบบแกนกลาง	URL: วิดีโอขั้นตอนการติดตั้งและเลือกอุปกรณ์	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:09:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:09:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:10:06	URL	Start การจัดวางอุปกรณ์และการเชื่อมต่อ	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:10:44	URL	Pause การจัดวางอุปกรณ์และการเชื่อมต่อ	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:10:48	URL	Pause การจัดวางอุปกรณ์และการเชื่อมต่อ	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:14:22	URL	Pause การจัดวางอุปกรณ์และการเชื่อมต่อ	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:18:00	URL	URL: การจัดวางอุปกรณ์และการเชื่อมต่อ	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:18:00	ระบบแกนกลาง	URL: การจัดวางอุปกรณ์และการเชื่อมต่อ	172.100.0.158	16	56	72
5901102057001	04/11/2017 16:18:12	URL	Start การตั้งค่าอุปกรณ์และการทดสอบ	172.100.0.158	16	56	72
5901102057001	04/11/2017 22:46:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	172.16.3.67	16	56	72
5901102057001	05/11/2017 10:39:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	192.169.136.65	16	56	72
5901102057001	05/11/2017 10:40:00	แหล่งข้อมูล	แหล่งข้อมูล: เอกสารประกอบการสอนชุดที่ 1	192.169.136.65	16	56	72
5901102057001	05/11/2017 10:40:00	ระบบแกนกลาง	แหล่งข้อมูล: เอกสารประกอบการสอนชุดที่ 1	192.169.136.65	16	56	72
5901102057001	05/11/2017 10:52:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	2001:44c8:4446:d6ed:1:2:af61:94c	16	56	72
5901102057001	05/11/2017 10:53:00	URL	URL: การจัดวางอุปกรณ์และการเชื่อมต่อ	2001:44c8:4446:d6ed:1:2:af61:94c	16	56	72
5901102057001	05/11/2017 10:53:25	URL	Start การตั้งค่าอุปกรณ์และการทดสอบ	2001:44c8:4446:d6ed:1:2:af61:94c	16	56	72
5901102057001	05/11/2017 10:55:13	URL	Pause การตั้งค่าอุปกรณ์และการทดสอบ	2001:44c8:4446:d6ed:1:2:af61:94c	16	56	72
5901102057001	05/11/2017 13:40:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	192.169.136.65	16	56	72
5901102057001	05/11/2017 13:56:00	Assignment	Assignment: ข้อที่ 1 จงออกแบบระบบเครือข่าย (N	192.169.136.65	16	56	72
5901102057001	05/11/2017 13:56:00	ระบบแกนกลาง	Assignment: ข้อที่ 1 จงออกแบบระบบเครือข่าย (N	192.169.136.65	16	56	72
5901102057001	05/11/2017 13:57:00	Assignment	Assignment: ข้อที่ 1 จงออกแบบระบบเครือข่าย (N	192.169.136.65	16	56	72
5901102057001	05/11/2017 13:57:00	Assignment	Assignment: ข้อที่ 2 จงอธิบายวิธีการเลือกอุปกรณ์	192.169.136.65	16	56	72
5901102057001	05/11/2017 13:57:00	ระบบแกนกลาง	รายวิชา: 252201 Computer Networks	192.169.136.65	16	56	72
5901102057001	05/11/2017 13:57:00	ระบบแกนกลาง	Assignment: ข้อที่ 2 จงอธิบายวิธีการเลือกอุปกรณ์	192.169.136.65	16	56	72

Figure 4 The sample data on learner behavior during activities.

The data recorded as CSV File before being uploaded into the Disco Program were shown in Figure 5**.**

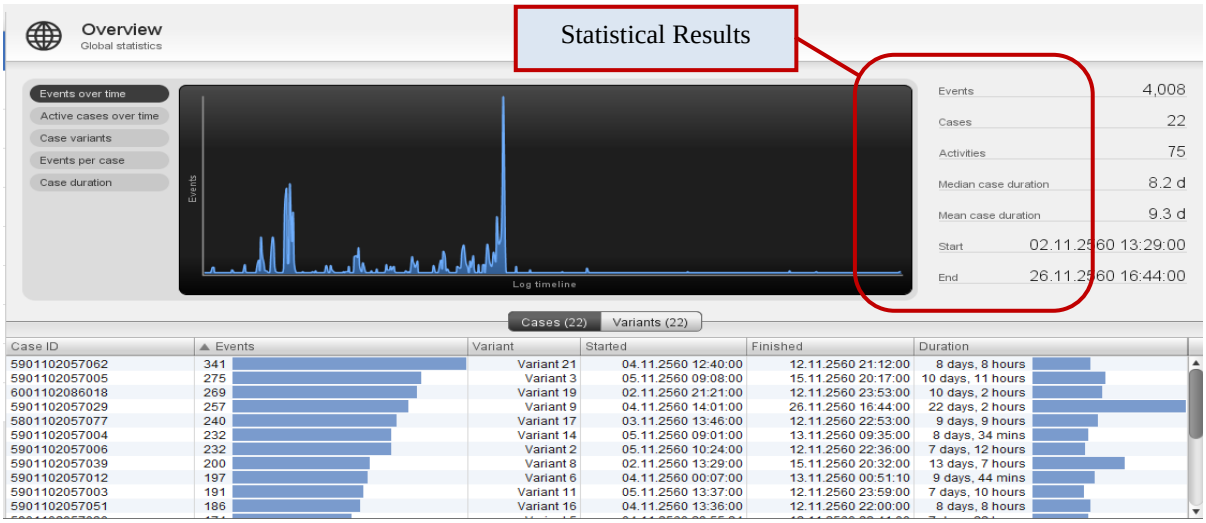


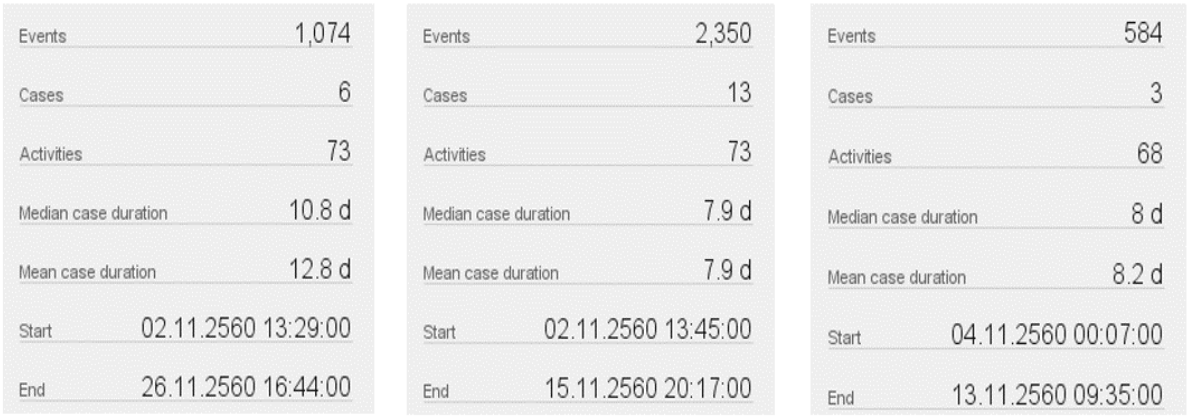
Figure 5 Statistical Results

From Figure 5, from the overview of statistical values from behavior data of samples during activities, it was found that there were 4,008 events and 22 cases occurring. There were 75 activities occurring. The median of the time of learning access was 8.2 days at the Average attendance of 9.3 days.

The researchers filtered the data by using the Disco program for grouping students according to their academic achievement. Which can be divided into 3 groups as shown in Figure 6, consisting of (1) learners who have 70% of academic achievement or higher, found that there are 6 learners for such group, (2) learners with academic achievement of 50-69% or more, found that there are 13 learners, and (3) learners who have lower academic achievement than 50%, found that there are 3 learners. The high achievement group spent 12.8 days on their study times and did 1,074 events. There are 73 activities and 6 cases accounted for 26.80% of all events.

The middle achievement group spent 7.9 days on their study times and did 2,350 events. There are 73 activities and 13 cases accounted for 58.63 % of all events. The low achievement group spent 8.2 days on their study times and did 584 events. There are 68 activities and 3 cases accounted for 14.57 % of all events. The workflow diagram would be presented to show the sample behavior during the activity, analyzed from Frequency of activities with Fuzzy model between the learner group of academic achievement of 70% or higher, shown in Figure 7, and the one of lower than 50%, shown in Figure 8, it was to analyze the frequency of learning activities of both 2 groups;

The workflow diagrams showing the behavior of the sample group during the activity by analyzing the duration of the activity by using Fuzzy model between learners with 70% learning achievement or more, shown in Figure 9, and the one of lower than 50%, shown in Figure 10 for analysis of the different timing of the learning activities of the two groups.



Statistical high achievement group | Statistical middle achievement group | Statistical low achievement group

Figure 6 Static values of learners classified by the achievement of learning.

Work Flow diagram showing the behavior of the sample group during the activity by analyzing the frequency of the activity by using the Fuzzy model would be shown in Figure 7 and 8.

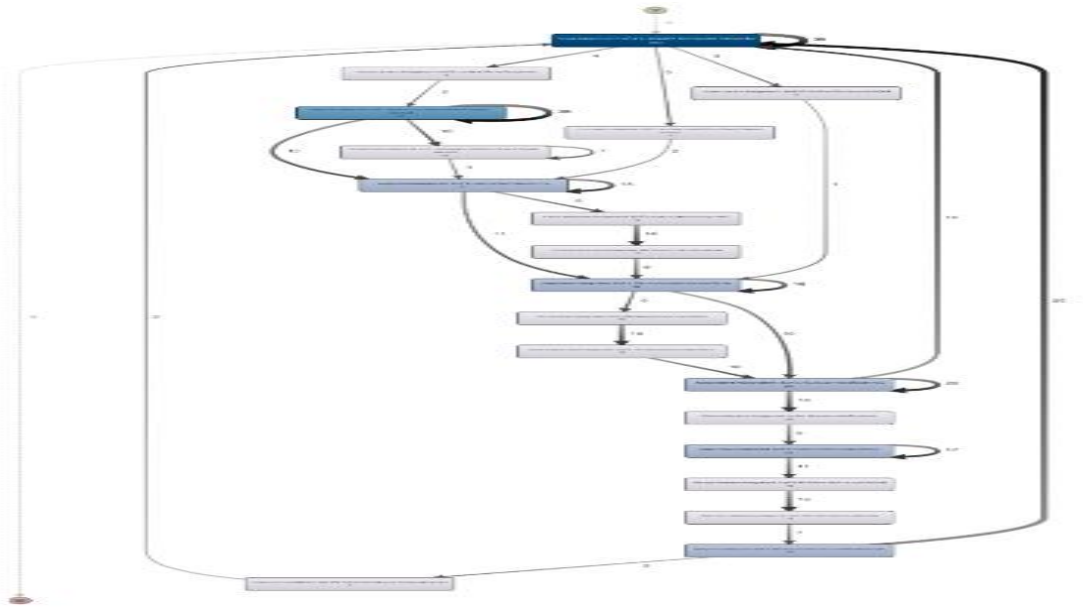


Figure 7 Diagram of Work Flow Behavior of the sample group during the activity by analyzing the frequency of the activity by using the Fuzzy model on the one of 70% or higher.

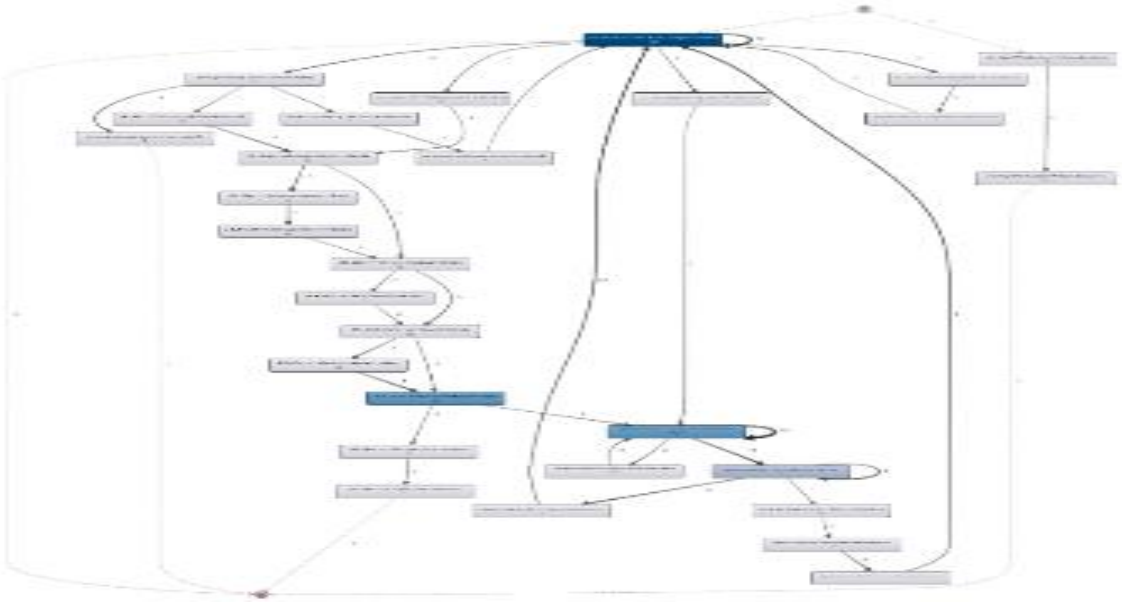


Figure 8 Diagram of Work Flow Behavior of the sample group during the activity by analyzing the frequency of the activity by using the Fuzzy model on the one of less than 50%.

For the illustrated learning behaviors of the high and low achievement groups, both groups did two activities: network diagram and device installing most frequently. This is because students had to solve network problems. They had to read, get information from the case study, and then analyze in order to solve the network problems. The Figure showed the workflow that students reread the case study and did the activities many times. This workflow demonstrated the learning behaviors of students clearly, so it is useful for teachers to use as inputs for adapting their teaching to suit their students.

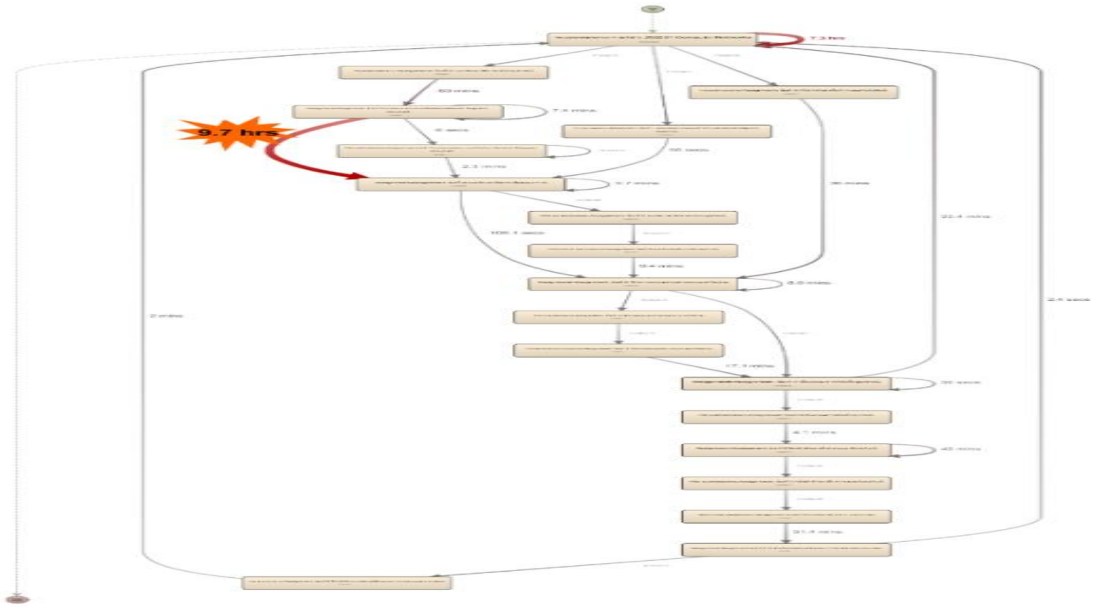


Figure 9 Work Flow diagram showing the behavior of the sample group during the activity by analyzing the duration of the activity by using the Fuzzy model on the one of 70% or higher.

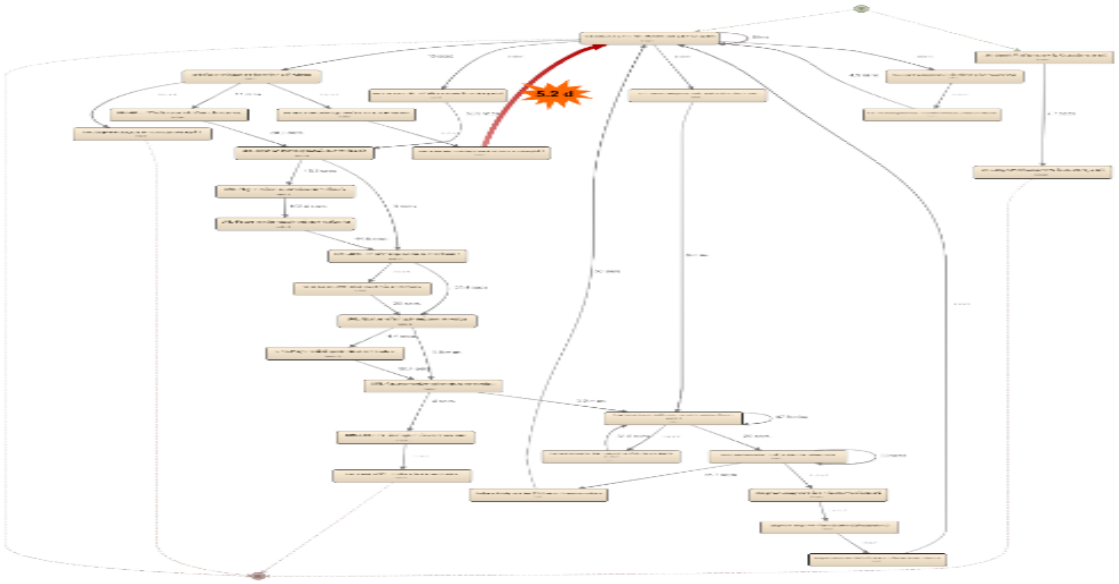


Figure 10 Work Flow diagram showing the behavior of the sample group during the activity by analyzing the duration of the activity by using the Fuzzy model on the one of lower than 50%.

Figure 9 and 10 showed frequency of time spent on doing activities by Fuzzy model by both high and low achievement groups, but the results did not reflect the learning achievement clearly. Thus, the researchers use Fuzzy model to analyze the duration of time spent on doing activities by Fuzzy model to compare between the high and low achievement groups. The high achievement groups took longer times to study (9.7 hours); whereas, the low achievement group spent much less time (5.2 hours).

Discussion

1) Learning achievement: After learning by using active learning and E-contingent learning models for teaching computer network design, the mean score of post-test was significantly higher than that of the pre-test. The standard deviation of post-test could spread out more than that of the pre-test. This can be implied that students' performances have improved through the employment of active learning and E-contingent learning methods in teaching. Moreover, it could show that applying the technique of Process Mining by using Fuzzy model on the behavior study of the learners could provide a clear understanding of learners' behaviors and could result in the ability of instructors for better adjustment of instructing practice to be more suitably flexible.

2) Students' satisfaction: After learning by using active learning and E-contingent learning models for teaching computer network design, students rated their satisfaction at the high level and the standard deviation value was less than 1. This can be interpreted that most students have their positive feedbacks of satisfaction with this teaching technique.

Limitation and Suggestion

The conducted study has some limitation such as the time and the number of participants. The time spent during the study was rather short unsuitable for practical observation of the whole process. The number of students participating in the study became too small for practical study. Therefore, for further study, a bigger one should be recommended to practically practice in order to gain a better concise result.

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