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Research Article

The effect of problem-based learning and tacit knowledge on problem-solving skills of students in computer network practice course

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Article Info

Abstract

This study aims to examine the effect of problem-based learning and tacit knowledge on problem-solving skills when students study in the laboratory. The method employed in this research was Quasi-Experimental Design. Data collection techniques were questionnaires and tests. Seventy-seven students were taken as the research participant and divide into two groups; 35 students in the experimental group with problem-based learning implementation and 42 students in the control group with procedural instruction. Questionnaires were used to measure tacit knowledge adopted from Insch, McIntyre, & Dawley (2008), Chilton & Bloodgood (2007), Somech & Bogler (1999). Data analysis techniques used two-way ANOVA test to determine learning outcomes. The research found that problem-based learning has a significant effect on problem-solving skills, and the use of tacit knowledge depends on the learning model. The results showed that problem-based learning could improve the ability of problem-solving while learning outcomes indicate that students use their tacit knowledge for problem-solving.

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Introduction

The widespread use of computer networks makes computer network learning a must for many universities and colleges in the Department of Informatic Engineering (Yang, 2018; Guan, 2017). Students take computer network courses to gain knowledge about how the Internet works, how the Web works, how to set up networks, and how to configure systems to deliver various applications (Liu, Fu, Li, & Yang, 2015).

The subject of computer networking is the first professional basic course in Informatics Engineering, Computer science and technology, and related majors (Zaus & Krismadinata, 2018). The conventional learning model is listened passively to students (Ling, Jing, & Shuxin, 2017) so that students lack initiative in the learning process and cannot improve their independent thinking skills.

The existence of practicum supports computer network course (Wei, 2017; Liu, Fu, Li, Yang, 2015). Lecturers are required to innovate in teaching methods and teaching media. Computer networks contain theories that require proof and experiment (Zhang, Li, Lu, & Li, 2016) because they cover a very technical approach.

Limited hours of computer network practice make computer network lectures dependent on the teaching methods of lecturers and the availability of efficient equipment (Juuso, 2018). Lecturers need alternative teaching methods to deliver material to students. Teaching methods that can deepen content, learning that is more dynamic and innovative,

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and students are better mastered and able to solve problems on computer networks. The complex unstructured problem requires effective problem solving in different domains (Funke, Fischer, & Holt, 2018).

Problem-solving capabilities are an essential variable among the main objectives of the current curriculum (Ozturk & Guven, 2016). Engineering graduates need to acquire and demonstrate a series of generic skills such as communication, problem-solving, and interpersonal relationships that must prepare for future employment. All these attributes can be through the implementation of the problem-based learning approach (de Villiers Scheepers, Barnes, Clements, & Stubbs, 2018).

Problem-based learning can improve problem-solving skills, including the students' problem-solving skills majoring in management (Kadir et al. 2016), vector analysis (Mushlihuddin, Nurafifah, & Irvan, 2018), dental education (Alrahlah, 2016), Virtual Reality Environment (Abdullah, Mohd-Isa, & Samsudin, 2019). Problem-based learning provides better benefits compared to conventional models (Hursen, 2019).

The weakness of the problem-based learning approach lies in the individual factor. This factor can influence problem-based learning implementation also consequently affect learning outcome (Hung, 2011). This research measures the influence of individual factors, namely students' tacit knowledge on the success of the problem based learning approach implementation.

Tacit knowledge is experience and skill as a way to overcome the challenges of unexpected problems that require immediate solutions (Ibidunni et al. 2018). Tacit knowledge becomes vital in the learning process (Krátká, 2015; Tee & Karney, 2010) because students can solve problems quickly so that academic performance become better (Matošková, 2019). Tacit knowledge is not just an activity of motor skills, but on understanding and realizing it practically (Andersson & Östman, 2015). Besides, tacit knowledge cannot replace in a variety of practical applications (Park, Vertinsky, Becerra, 2015; Wang, Su, Hsieh, 2011).

Problem of Study

According to the background that has outlined, the research problem is examining the influence of problem-based learning and tacit knowledge towards problem-solving skills in computer network practicum. The research questions are as follows:

➢ Is there a significant difference in the problem-solving skill, students who use problem-based learning models and procedural instruction models?

➢ Is there a significant difference in the problem-solving skill, students who have high tacit knowledge and low tacit knowledge?

➢ Is there a significant interaction between the learning models and tacit knowledge with the ability to solve problems?

Method

Research Design

A quasi-experimental design was applied in the study with a non-equivalent control group because there were in the condition of impossible to control all relevant variables. Participant in this study of 4th-semester students who were taking the course of a computer network practicum majoring in Informatics Engineering at Islamic State University of Maulana Malik Ibrahim. Participant consists of two groups, namely experimental and control group. The participant randomly selected for inclusion in experimental groups and control groups.

Participants

Participant in this study was 77 students from a population of 151 students, consisting of 35 students was an experimental group and a control group amounting to 42 students. The number of participants, according to Federer's formula (Federer, 1967), follows the following formula.

$$(t-1)(n-1) > 15$$

where t = number of treatments, n=number of participants

Students in this study were in the 4th semester. The participant distribution of this research as seen in table 1.

Table 1.

Participant Distribution by Gender

Group	Gender	N
Experimental	Male	20
	Female	15
Control	Male	29
	Female	13
Total	Male	49
	Female	28

The experimental group uses the problem-based learning (X1) model and the control group with the procedural instruction (X2) model, as illustrated in table 2. Pre-test (O1 and O3) was given to know students prior knowledge. The participants need to complete the tacit knowledge questionnaire before the learning process to measure their level of tacit knowledge. Participants were given the post-test (O2 and O4) to compare the outcomes of the problem-solving skill in the control and experimental groups.

Table 2.

The Control and Experimental Groups Implementation

Participant	Pre-test	Implementation	Post-test
Group A (Experimental)	O1	X1	O2
Group B (Control)	O3	X2	O4

Data Collection

Pre-tests were conducted against 77 students (42 participants in the control and 35 participants in the experimental groups) to get the initial ability. The use of the group technique to control the weakness in sorting or in the selection of samples (Setyosari, 2016). The treatment was implemented for four weeks after pre-test and tacit knowledge measurements. The experimental group was assigned a problem-based learning model, and a control group used procedural instruction.

Data collection uses a questionnaire and test sheet. The questionnaire was prepared to obtain students' tacit knowledge level. The questionnaire used to classify students with categories of high and low tacit knowledge. The test sheet prepared to get the learning outcome on problem-solving skills in a computer network practicum. It represents the aspect of problem-solving skills. Validity test was given to the experts to ensure that the tool is ready for use.

Problem-Based Learning Implementation

Problem-based learning implementation based on Arends (2012), as shown in table 3.

Table 3.

Problem-Based Learning Implementation

Problem-based Learning Syntax	Realization
Identification of problems (Student finds the problem)	Presentation of Learning Objectives and the actual problem was given to the students. A summary of the actual problems given to the students.
Organizing the student	Students divide into five groups. The instructor discusses the experimental design of each group. The instructor provides instructions for solving problems.
Monitoring and investigation	The instructor guides students to gather appropriate information. The instructor guides students to look for explanations and problem-solving
Development and presentation of the results of problem-solving	Students make reports and present the results of problem-solving.
Problem-solving process analysis and evaluation	The instructor helps students to analyze and evaluate the process of problem-solving.

Figure 1.

Monitoring and Guidance by the Instructor in Instructional Activity

Figure 1 shows monitoring and guidance by the instructor in the experimental group. Students divided into small groups of three or four and took roles as computer network designers. Their client is a faculty of Science and Technology who asks computer network designers to design computer networks for educational use. In this study, there were three problem-based learning sessions, the previous session supporting the next session. At each meeting, participants carry out the following activities:

Session 1 (week 1) is a preliminary activity beginning with the calculation of IP addressing, subnetting, and netmask. The focus of session 1 is to motivate students to use their knowledge and apply it to produce an outline design that will form the foundation of the first meeting between students and client.

Session 2 (week 2) is a follow-up activity to design the Local Area network. This design has not yet identified the client's desire. In session 2, students learn how to determine the client's needs on a computer network, deciding which technology is most suitable for meeting these requirements. Room conditions in buildings can also affect network design.

Session 3 (week 3 & 4) are the client wants, which influences how students can carry out their plans. This design is following the wishes of the client, namely a computer network for educational usage.

Data Collection Tool

Tacit knowledge measurement scale refers to the Tacit Knowledge Academia adopted from Insch, McIntyre, & Dawley (2008), Chilton & Bloodgood (2007), Somech & Bogler (1999). An expert validates the measurement scale to check its ambiguity and provides advice. The results of the expert then tested for validity checks on participants other than the experimental and control groups. The participants consisted of twenty students majoring in informatics engineering with an average age of twenty years. The results obtained 18 items valid tacit knowledge measurement includes dimensions of self-motivation skills (2 items), self-regulating skills (2 items), individual technical skills (3 items), institutional technical skills (1 item), interaction related tasks (3 items), social interaction skills (1 item), awareness (5 items), demonstration ability (1 item). The coefficient of Cronbach alpha test is 0.916. Furthermore, the instrument can be used for data collection.

The Measurement of learning outcomes using problem-solving rubric adopted from the Common Core State Standards (CCSS) in the 21st century (Greenstein, 2012). This assessment rubric consists of identifying the problem, identifying multiple solutions, and defending solutions.

Data Analysis

Data tested using analysis of variance to compare the mean, which classified into two factors or two classifications. The Data was analyzed to examine whether there was a significant difference between the experiment and the control groups over the problem-solving capabilities, whether there was a difference in high and low tacit knowledge of the resolving ability of the problem and whether there was an interaction between tacit knowledge and learning models. The Data were analyzed using SPSS 23. The testing of statistical values is at 5 % significance.

Results

In this study, the independent sample t-test was employed to calculate whether there was a significant difference between pre-test and post-test on problem-solving skills. The comparable on the mean score is illustrated in table 4.

Table 4.

Comparison of Mean Score on Problem-Solving Skill

Test	Mean		Mean difference	p-value
	Control group	**Experimental group**		
Pre-test	69.24	67.26	1.98	0.124
Post-test	65.92	76.02	10.1	0.000

Independent sample t-test conducted to measure significant differences between the learning outcomes of the control and the experimental groups. The experimental and control groups result can be seen in table 4. There is no significant difference between the control and experimental groups (p-value> 0.05) in the pre-test. Likewise, it is seen that the post-test mean of the experimental group is better than the control group. The results of data analysis obtained a p-value <0.05. It can conclude that there are significant differences between the experimental and the control groups.

Table 5.

Mean Score of Post-test on Problem-Solving Skill

Tacit Knowledge	Group	Mean	Std. Deviation
Low	Experimental	68.600	4.08482
	Control	64.600	7.57002
	Total	66.314	6.55193
High	Experimental	81.600	5.43284
	Control	67.136	7.51694
	Total	74.023	9.80166
Total	Experimental	76.029	8.12218
	Control	65.929	7.55917
	Total	70.520	9.27165

There are problem-solving skill differences based on students' tacit knowledge level (high and low). Student learning outcomes as in table 5. Appropriate learning models can pick up from the average learning outcomes of the two methods. The total mean as in Table 5 shows that the problem-based learning model is 76.029, and in the procedural instruction model is 65.929. The post-test mean of the problem-based learning model was high when compared to the post-test mean of the procedural instruction model group. Descriptively shows the implementation of problem-based learning has a better influence on students' problem-solving skills in computer network practicum.

Table 6.

Test of Normality

	Kolmogorov-Smirnov		
	Statistic	**Df**	**p-value**
Standardized Residual	0.088	77	0.200*

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 7.

Levene's Test of Equality of Error Variances

F	df1	df2	p-value
1.661	3	73	0.183

The normality and homogeneity of data requirements must fulfil before ANOVA analysis. The normality test using Kolmogorov-Smirnov is 0.200, as shown in table 6. The normality test results, as presented in table 7, show that the significance value is higher than 0.05, so it can state that the research data normally distributed. The Levene's test, as shown in Table 7, the p-value is greater than 0.05, which means that all data is homogeneous. A hypothesis test can be performed because the research data is normally distributed and homogeneously.

Table 8.

Analysis of Univariate Test Results

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2295.368a	3	765.123	16.447	0.000
Intercept	366689.752	1	366689.752	7882.540	0.000
Learning Model	1147.937	1	1147.937	24.677	0.000
Tacit Knowledge	736.072	1	736.072	15.823	0.000
Learning Model* Tacit Knowledge	272.623	1	272.623	5.860	0.018
Error	3395.905	73	46.519		
Total	380057.000	77			
Corrected Total	5691.273	76			

a. R Squared = 0.403 (Adjusted R Squared = 0.379)

The probability value of the learning model is <0.05, as seen in table 8. It means that the null hypothesis is rejected. It can be stated that there is a difference in the problem-solving abilities of students who learn with problem-based learning model and procedural instruction learning model. The probability value of tacit knowledge is <0.05; consequently, the null hypothesis rejected. It means that there is a difference in problem-solving skill of students who have high tacit knowledge and low tacit knowledge. The probability value of the learning model * Tacit knowledge is <0.05); consequently, the null hypothesis rejected. It means that there is an interaction between the learning model and tacit knowledge in problem-solving skills.

Discussion and Conclusion

Problem-solving skill is one of the abilities obtained through learning. Solving problems involves activities such as using basic thought processes to solve specific difficulties. Problem-solving skill is one way to see the mastery of concepts because in solving problems students must know the concepts and principles that will be used (Buteler & Coleoni, 2016; Docktor, Strand, Mestre, & Ross, 2015). Problem-solving skills require appropriate training and learning models. Students' problem-solving ability will be better with the right learning model (Çalişkan, Selçuk, & Erol, 2010).

The result of this study indicates that there is a significant difference in the pre-test and post-test result in the problem-solving skill of the experimental and control groups. This significant difference was better in the experimental group than in the control group.

The results of the first hypothesis testing showed that there were significant differences in the problem-solving abilities of students of the computer network practicum between groups of students who given the problem-based learning model and procedural instruction model. The average results from the ability to solve problems of students who learn through problem-based learning are higher ($\bar{X}$=76.02) than through procedural instruction ($\bar{X}$=67.26), which means that problem-based learning provides the ability to solve problem greater than using procedural instructions in computer network practicum.

Based on the results in this quasi-experimental study, it found that students who learn in problem-based learning and the procedural instruction model had significant differences in problem-solving abilities. Students who learn in the problem-based learning model had higher problem-solving skill than students who learn in the procedural instruction model. Problem-based learning model has a significant effect on the achievement of problem-solving skill in the computer network practicum. Thus, problem-based learning is more effective in enhancing problem-solving abilities (Jabarullah & Hussain, 2019). The application model of learning can enhance students' problem-solving skills. The learning process requires the right model to get the results of learning on problem-solving skill. The learning process is to link new knowledge to the cognitive structures that students have (Degeng, 2013). Consequently, the selection of learning models certainly adjusted to the conditions of students, and the learning environment.

The ability to solve problems is the goal of the problem-based learning model. The results of this study are in line with the results of research by Mushlihuddin, Nurafifah, & Irvan (2018), Ma & Lu (2019) that the problem-based learning model can effectively enhance students' low ability to solve the problem. Students faced with complex and

contextual issues that solve together with their study groups related to learning material. Hence, students are accustomed to solving problems in the learning process.

Thus, the result of this study indicates that problem-based learning can help students with uncertain structured problem-solving processes and improve problem-solving skills as similarly done by Hendriana, Johanto, & Sumarmo, (2018). Learning based on problem-based learning modules conducted by Arini, Hartono, & Khumaedi (2019) can improve the ability to solve physics problems. This study took one class as an experimental group treated in problem-based learning with problem-based learning modules. The six students selected from the experimental class to make more in-depth observations about problem-solving skills. It concluded that the problem-based learning module had been effective in improving students' physics problem-solving skill.

The result of this study concludes that the problem-based learning model was not designed to help instructors provide as much information to students. It was developed to help students improve problem-solving skills and their involvement in real experiences in the form of simulations, and become student-focused learning. The problem-based learning model is more challenging because learning begins with a real problem encountered in work (Pardimin, Arcana, & Supriadi, 2019). Students placed as the main actors in learning activities and encouraged to be more creative in solving the problems they face. These problems related to the material taught to the daily lives of students. The instructor, as a facilitator, is fully responsible for identifying learning objectives, material structure, and necessary skills to be taught.

The result of the second hypothesis testing showed that there is a significant difference in the ability of students to solve problems in practicing computer networks between groups of students who have high tacit knowledge and low tacit knowledge. Tacit knowledge is past experience, organizational specific knowledge, community contextual knowledge, and acknowledgment of the tacit knowledge of others (Kothari, Bickford, Edwards, Dobbins, & Meyer, 2011).

Engel (2008), in his research, said that tacit knowledge is essential in medical education. Goffin & Koners (2011) stated in their research on new product development, that problem-solving ability related closely to tacit knowledge. Peng (2014) also says that tacit knowledge is personal knowledge. The problem-solving ability of the teacher in the classroom involves tacit knowledge. Tacit knowledge is a type of practical knowledge obtained from experience. The teacher's problem-solving ability is tacit knowledge gained from teaching experience.

Based on several findings in these studies, individual tacit knowledge can affect students' ability to solve problems. The use of students' tacit knowledge influenced by the condition of students when learning is taking place. Learning models that are following the conditions of students can lead to the use of tacit knowledge to solve problems in computer network practice.

The third hypothesis testing in this study showed that there was a significant interaction between teaching using problem-based learning and procedural instruction with tacit knowledge on problem-solving ability in computer network practicum. Students who have high tacit knowledge have higher problem-solving skills than students who have low tacit knowledge on problem-based learning and procedural instruction. This result is similar to the results conducted by Lou et al. (2010) that problem-based learning influences students' tacit knowledge. Brock (2017) also said that the tacit knowledge possessed by students influences the learning model of problem-solving abilities.

Pemsel & Müller (2012) argues that tacit knowledge created in mind as personal knowledge and expressed as innovation. His research on entrepreneurship learning in new companies as a method of developing entrepreneurship is a way of creating individual knowledge rather than entrepreneurship education. The dimensions of entrepreneurship development in a new company are significantly related to tacit knowledge.

This study intended to examine the effect of problem-based learning and individual tacit knowledge on problem-solving abilities in computer network practicum. The results showed that the use of problem-based learning model is better than the procedural instruction in computer network practicum. The experimental and control groups show the ability to solve problems better after the learning process. However, the experimental group using problem-based learning got better learning outcomes than the control group. There is an interaction between the problem-based learning model and the student's tacit knowledge (Lee, 2017). The problem-based learning model can lead students to use students' tacit knowledge to solve problems.

Limitations

It is essential to know that there may be unique circumstances in this course that do not apply to all undergraduate programs of informatics Engineering. There may be variables which affect tacit knowledge (e.g. Gender, learning styles) that results in a difference in problem-solving skill. These variables were not investigated in this study.

Recommendations

Several recommendations can be given related to this study. In terms of recommendations for instructors acting as facilitators, they will improve their quality and competence in teaching and building relationships so that they can do their job with good and maximal results. For future research, it is highly recommended to investigate the factors influencing the tacit knowledge of students and whether the students' tacit knowledge is influential to the other learning models or vice versa. This research can be used as a comparative ingredient for future relevant research, and future researches involving other variables that affect the problem-solving skill are also welcomed. Additional studies should be conducted in a variety of computer networking topics to see tacit knowledge influence on the ability to resolve problems.

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