

# An Evaluation of Problem-based Learning Supported by Information and Communication Technology: A Pilot Study

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## Abstract

This pilot study aimed to identify the effectiveness of Information and Communication Technologies (ICTs) in supporting the Problem-Based Learning (PBL) method and the Traditional Teaching Method (TTM) through students' examination scores. The research design was a quasi-experimental post-test design, where bivariate analysis using the Wilcoxon statistical test was used to determine the difference in the examination scores between the applied learning methods. It is found that the support of ICT applications increases students' examination scores from both the TTM and PBL method. However, it only yields a significant increase when used in the PBL method or when the PBL method is combined with TTM. Among all the methods evaluated, the PBL method with ICTs support gave the highest results in students' examination scores.

**Keywords:** Problem-based learning; Information and communication technologies; Traditional teaching method; Evaluation; Examination scores

## Introduction

Science and technology in the field of nursing have developed rapidly over the past few decades. In nursing practice, the use of Information and Communication Technologies (ICT) in the form of mobile application have been developed for many health interventions such as for heart failure [1], for thyroid cancer [2], for supporting diffusion of traditional medicine [3]. In nursing education, the need to produce nursing graduates who are competent to deal with various health cases has also grown rapidly. Therefore, it is considered very important to have a learning process in nursing education that can create graduates with good study skills and a high self-learning motivation as a basis for their future lifelong learning. Lifelong learning means that every nurse has to be able to continue learning during their entire life, especially while they are working or interacting with patients. One of the ways to develop study skills and self-learning motivation in nursing students is by adopting the concept of the adult learner. In this sense, nursing students are assumed to be adult learners instead of young learners, who

have the main responsibility for their own learning process. Hence, this concept shifts from the traditional learning concept, in which teachers play the central role in the success of the learning process, to the students being central to the learning process. Playing the central role in their own learning process, the students are intensively encouraged to be more active in fulfilling their learning needs. This is also known as self-directed learning. It is suggested that nursing educators improve the learning process by implementing self-directed learning [4]. One of the learning methods that emphasize self-directed learning is known as Problem-Based Learning (PBL). PBL not only supports self-directed learning, but it has also been found that it can enhance students' critical thinking skills. Yuan et al. [5] indicated in their study that the PBL method yields greater results in terms of critical thinking skills than the Traditional Teaching Method (TTM). It is also more efficient and effective in developing the necessary skills to provide effective case management [6]. Several components of critical thinking are the students able to gather information, investigate, do analyzing, and solve the problem [7]. A bit similar to PBL, another method of learning that can develop students' characteristics such individual growth and important life skills such as critical thinking is Team-Based Learning. When students work in small groups, communicate and learn in team, it will enhance the performance of learning teams. A study found that TBL was experienced positive by the students. It also brings positive emotion for students [8], however it is oriented to task not problem case given.

PBL as a student-centered learning concept has been adopted by many health education institutions, including the Nursing School of Riau University. However, some parts of TTM are also used. The combination of the PBL method and TTM is known as a hybrid curriculum. Officially, the Nursing School of Riau University started adopting PBL as a teaching method in 2012. Since then, several research studies on the effectiveness of PBL have been conducted in this institution [9,10].

A number of studies related to the effectiveness of PBL have investigated [9-14]. A study that is conducted in Nursing School of Riau University showed that PBL had positive effects on students' examination scores even with very limited supporting facilities [9]. The same location of investigation is reported by Ernawaty [10], it is found that students got the highest

examination scores when PBL was modified, with the lecturer being replaced as group tutor by a group member who was considered to be competent. The implementation of PBL did not result in students getting better examination scores, even when compared to TTM. A similar result was shown by Beer [11], that there was no difference in student examination scores between the PBL and TTM groups. However, Shin et al. [14], in their meta-analysis, reported that the implementation of PBL had a positive effect on students' examination scores, although with a relatively large standard deviation value of 0.70.

In term of graduation competency, Koh et al. [12] found in their systematic review that, PBL has positive effects on physician competencies after graduation. Furthermore, it is also reported that there was a positive effect of the PBL method when combined with e-learning media [13]. The purposes of this pilot study are: first, to compare the effect of the PBL method and TTM on students' examination scores; and, secondly, to evaluate the effect of ICTs support on the PBL method and TTM, also by using students' examination scores.

This pilot study is considered of importance as it contributes as follows:

- This pilot study identifies the effectiveness of PBL and TTM in combination with using ICTs, and without using ICTs, through analyzing examination scores. This is the first study of nursing education in Indonesia.
- We use ICTs in terms of computerization and Internet media used by the students to collect various health case scenarios and learning materials. These learning materials will be brought to interactive group discussion.
- We present open-ended questions that can stimulate the students. Each student is obliged to comment on the questions given in the provided media.
- We expect in the future that integrating the PBL method and TTM with ICTs support can be suggested as an effective and interactive learning method, especially in nursing education.

The rest of this paper is organized as follows. Section two describes PBL, TTM, and ICTs. Section three is the research method. Section four explains the results. Section five is the discussion, and section six presents the conclusion.

## PBL, TTM and ICTs

This section discusses the development of PBL as a student-centered learning method, TTM, and the use of ICTs in education.

### Problem-based learning (PBL)

The recently developed PBL method is an innovation in health education systems that originally started in Canada. Various experts have given similar definitions of the PBL method. Barret [15] defines PBL as a form of enquiry-based learning with the characteristic that problems are given at the beginning of the learning process. In line with her previous definition, Barret [16] in her new model PBL defines it as a learning method that using problems with four characteristic which are the problem, the PBL tutorial, the PBL process and learning. In addition to this,

Savery [17] defines the PBL method as an instructional (and curricular) learning approach, which is centered on the students. The students are encouraged to conduct investigations, integrate theory with practice, and implement knowledge as well as their skills to develop solutions to real problems. The key success of PBL implementation lies in the selection of ill-structured problems and competent tutors who can direct experiences in the learning process. Donnelly [18] defines PBL using the approach of constructive learning theory. He stated that PBL is a pedagogic approach that suggests that previous knowledge is used as the basis for forming new knowledge. When students with different prior knowledge follow a learning process, a pedagogic approach is required to consolidate the varying prior knowledge in order to develop new knowledge.

The Faculty of Health Science, University of McMaster uses its own self-learning approach to implementing PBL. PBL is defined as a primary learning method, where health cases are considered as a stimulus and a guide for the student learning direction. This is quite different to problem-solving. The aim of learning is not to solve problems but to help students identify their self-learning needs by understanding problems, drawing conclusions, synthesizing and utilizing information gathered from the problems, and working actively to learn from their groups and tutors. In addition, Walsh [19] describes PBL in terms of small group learning and self-directed learning. There should be between five and eight members of each PBL group [15,20]. Self-directed learning means that students learn more independently and more actively than in TTM. This description is in line with the opinion of Chunta and Katrancha [21], who determine PBL as being an active teaching strategy. PBL gives the framework to develop self-directed learning, self-evaluation, interpersonal communication, critical thinking, and access to gaining information.

Several studies encourage the implementation of PBL [4,5,22]. It can increase critical thinking [5] and promote lifelong learning [4]. Moreover, Roh et al. [22] showed that it can be a good educational strategy when it is combined with other methods, such as simulation-based learning.

### Implementation of PBL

In the implementation of PBL, there are several kinds of procedures that consist of practically similar steps. The stepwise procedure of PBL is known as the seven jump method, although some authors use slightly different terminology [19,20]. The seven jump steps that are used at the Nursing School, Riau University, are as follows:

- Clarifying terminology, concept, and keywords,
- Determining problems,
- Analyzing problems,
- Performing systematic study from various explanations obtained in step 3,
- Formulating the goals of study,
- Collecting additional information outside the group discussion,
- Synthesizing and providing obtained information.

Through the PBL process, the students will learn to solve problems, acquire self-directed learning techniques, and

increase their skills in knowledge exploration from available resources.

### PBL versus TTM

Recently, there has been a strong suggestion to shift the current teaching method, which is teacher-centered, to a new teaching method that emphasizes student-centered learning. One of the student-centered learning methods is PBL. The PBL method adopts the philosophy of adult learners and lifelong learning. In TTM, information is passively transferred from tutors to students whereas, in PBL, the students are active participants in their own learning process. Students are placed as if they are in a real situation, where problem parameters may not be fully explained and can be worrying [23].

### TTM

TTM is a teaching method in which the teaching materials are transmitted and given by lecturers to students in traditional way. It is the conventional teaching method and the most method used in US, and suggested by evidence to be more effective along with others method [24]. It has been used in delivering knowledge since the very beginning of education. It might be accompanied by technologies such as computers, projectors, and the many advanced technologies that might be used in higher education. Many authors have argued for the effectiveness of TTM in higher education [14,25] and TTM is still an important part of the learning process. TTM is still the most effective method if it is implemented in a large class with a very large audience [26]. Other research has also proved that TTM can improve student achievement [27]. Hence, simply shifting the learning method from TTM to problem solving without attention to how far it is implemented may result in students achieving uncertain results.

Several strengths of TTM are lecturer can share intrinsic interest of the materials, give a role model, organize material in different way, communicate too many students at the same time, provide maximum teacher control [24]. It is a challenging situation where lecturer not only mastering the material but also makes it interesting and engaging to the students [26].

An example of the use of technology in traditional teaching method is podcasting. It brings benefits by increasing learning flexibility, enhancing access to learning and improving the learning experience of the students [28]. However, this technology was not combined with traditional teaching method in this study. Not just because the facility matter, but also because this will need specific funding.

### ICTs

The development of ICTs application in the education sector is growing rapidly. Tremendous investment has been made in information technology in education. It supports education and information transfer more effectively. The terminology of ICTs

application in education is also known as e-learning. Nevertheless, in this research, the author continues to use the term ICTs. ICTs improve the chance of lifelong learning, without boundaries. The year of 1990 is known as the beginning of communication decade where information access through computerization was widely opened up with the growing popularity of the Internet in a wide range of communities. In education, methods of learning also transformed in line with the development of ICTs applications.

### Definition ICTs

Donelly [18] described the use of ICTs in learning as a pedagogic approach that supports the constructive learning theory. This theory suggests that prior knowledge is used as the basis to form new knowledge. In a much simpler definition, Mikre [29] defines ICTs as the use of computers and the Internet as communication and information media for learning purposes. In Indonesia, the terminology of ICTs has been adopted as Teknologi Informasi dan Komunikasi (TIK). In 1970, a center for technology and communication for education was founded, and the term TIK was introduced [30].

The terminology of e-learning refers to a learning process that uses information from networks such as the Internet, intranet (Local Area Network), or extranet (Wide Area Network) that is used for course interaction and facilitation. Web-based learning is one type of e-learning that involves a learning process through the Internet, such as using Internet Explorer [29].

### ICTs implementation

ICTs were implemented in this pilot study as a technical support for PBL and TTM, not as a replacement of these two methods of learning. Google Apps for Education is used and is managed centrally at the ICTs center of Riau University. Tutors can use this application for sharing topic materials, disseminating power points, and establishing discussion forums.

## Methods

### Research design

The pilot study design that was developed in this study was a quasi-experimental one-group (pretest-posttest) design. One-group (pretest-posttest) design is a quasi-experimental design when only one group is involved [31]. Interventions were performed using PBL learning and ICTs methods, and their effectiveness was then compared. The implementation of this study can be seen in **Table 1**.

**Table 1** The implementation of ICT in applied learning methods.

Activities	Duration
<b>Week I (without ICT)</b>	
1 time PBL	6-hour tutorial (tutor 1, tutor 2, class sharing) and 4 hours' self-study
3 times Traditional Teaching Method (TTM)	6 hours
<b>Week II (with ICT)</b>	
1 time PBL	6-hour tutorial (tutor 1, tutor 2, class sharing) and 4 hours' self-study
3 times Traditional Teaching Methods (TTM)	6 hours

## Sample

All 72 students of program A, who were taking the management subject block in the second semester of 2015, participated in this study. The total sampling technique was used in this study.

## Ethical consideration

This pilot study was funded by the Research and Higher Education Directorate of Indonesia, approved by the Research and Community Development Center of Riau University, and conducted in Riau, Indonesia in 2015. Self-determination, privacy, and confidentiality were maintained in this study. Participants were also informed about the study before signing the consent form. They could refuse to participate, or withdraw from this study. The scientific value and ethical considerations of the research were reviewed by the Research and Community Center of Riau University.

## Data Analysis

A Wilcoxon statistical test was used to determine the difference in the examination scores between the learning methods applied. The level of significance was set at 0.05.

**Table 2** Students' examination scores from several applied learning methods (n=72).

Variable	Mean $\pm$ SD	Min-max
<b>Single method</b>		
PBL Non-ICT	4.61 $\pm$ 1.80	0-9
TTM Non-ICT	6.16 $\pm$ 1.40	2-9
PBL ICT	6.40 $\pm$ 1.99	2-9
TTM ICT	6.29 $\pm$ 1.20	3-9
<b>Combination methods</b>		
PBL + TTM Non-ICT	10.77 $\pm$ 2.60	5-16
PBL + TTM with ICT	12.69 $\pm$ 2.80	5-17

## Comparison of students' examination scores from several applied learning methods

The results of Wilcoxon tests on a comparison of students' examination scores from several learning methods are listed in **Table 3**. Without the support of ICTs, there was a significant

## Results

### Students' examination scores from several applied learning methods

The mean values of students' examination scores obtained from several learning methods and the availability of ICTs support can be seen in **Table 2**. Among single methods, it can be seen that the highest mean value of students' examination scores was 6.40  $\pm$  1.99 from the PBL method with ICT. Without the support of ICTs, TTM gave much higher students' examination scores, with a mean value of 6.16  $\pm$  1.40 compared to the mean value from the PBL method that was 4.61  $\pm$  1.80. On the other hand, with the support of ICTs, the PBL method gave just slightly better results in students' examination scores, with a mean value of 6.40  $\pm$  1.99 compared to the mean value from TTM that was 6.29  $\pm$  1.20.

When a combination of PBL and TTM is applied, ICTs support gave a much better result in students' examination scores, with a mean value of 12.69  $\pm$  2.80 compared to that without the support of ICTs, which had a mean value of 10.77  $\pm$  2.60.

difference between the students' examination scores from PBL and TTM (P value of 0.000). In contrast, the support of ICTs did not statistically result in any difference between students' examination scores from PBL and TTM (P-value of 0.577). When comparing the students' examination scores from TTM with and without the support of ICTs, there was no difference in the

results (P-value of 0.338). On the other hand, the comparison of students' examination scores from PBL with and without the support of ICTs gave a significantly different result (P-value of

0.000). In addition, when a combination of PBL and TTM was applied, the support of ICTs showed a significant difference in the students' examination scores (P-value of 0.000).

**Table 3** Examination score differences between learning methods applied (n=72).

Variable	Mean	P-value
<b>Single method</b>		
PBL (Non-ICT) compared to	4.61	0.000
TTM (Non-ICT)	6.16	
PBL (ICT) compared to	6.40	0.577
TTM (ICT)	6.29	
TTM (Non-ICT) compared to	6.16	0.338
TTM (ICT)	6.29	
PBL (Non-ICT) compared to	4.61	0.000
PBL (ICT)	6.40	
<b>Combination method</b>		
PBL+TTM (Non-ICT) compared to	10.77	0.000
PBL+TTM (ICT)	12.69	

## Discussion

This pilot study evaluates the effects of the PBL method and TTM with and without the support of ICTs on students' examination scores. On the implementation of the PBL method and TTM without ICTs support, this pilot study indicated that the students' examination scores from TTM were higher than those from PBL. The difference between the scores from both methods was statistically significant. This finding is consistent with previous studies indicating that TTM is associated with higher student achievement [27]. In addition, Ernawaty [10] found that TTM resulted in better students' examination scores compared to the PBL method. However, these findings are not in agreement with the results of other studies performed by Gurfinar et al. [13] and Shin et al. [14]. Both authors concluded that the implementation of the PBL method results in better students' examination scores than TTM. Despite this, another pilot study performed by Beer [11] came to a different conclusion, stating that there was no difference in examination scores between PBL and TTM. These different findings suggest that further evaluation is required to assess under which conditions the implementation of PBL or TTM is effective. The higher level of students' examination scores from TTM found in this research may be because of certain lecture materials given in TTM, whereas when using the PBL method, study materials can come from various sources; this gives rise to uncertainties, and students take more time and make more effort to answer the examination questions properly. Therefore, simply changing the method from TTM to PBL without concern for the best mode of implementation will not make a significant impact on student achievement [27].

On the implementation of the PBL method and TTM with the support of ICTs, this pilot study found that students'

examination scores from the PBL method were slightly higher than those from TTM. However, the examination scores were not statistically different. In addition to this, when comparing the results of TTM without the support of ICTs with the results of TTM supported by ICTs, this pilot study also found similar results. TTM with ICTs support gave slightly better students' examination scores than TTM without ICTs support. The difference in the examination scores from both TTM with and without ICTs support was not significant. In contrast, the comparison of students' examination scores when using the PBL method with ICTs support with PBL without ICTs support was significant. The PBL method with ICTs support gave much better students' examination scores than the PBL method without ICTs support. Furthermore, this trend was also true when comparing a combination of the PBL method and TTM with ICTs support to a combination of the PBL method and TTM without ICTs support. A combination of the PBL method and TTM with ICTs support gave much better students' examination scores than a combination of the PBL method and TTM without ICTs support, and the difference was statistically significant. In general, this study indicates that the application of ICT support increases the results of students' examination scores in both the PBL method and TTM as well as their combination, although the increase is only significant for the PBL method rather than for TTM.

The positive effect of ICTs application support on several learning methods found in this pilot study is consistent with the findings of several previous studies. Lee et al. [32] found a positive effect of web-based problem learning (W-PBL), self-regulated learning (SLR), or a combination of the two for low-achievement students. Although this study did not evaluate student examination scores, the finding recommends using an innovative instructional technology to redesign and explore the benefit of web-based learning or what has been called ICTs in

this study. In addition, Gurfinar et al. [13] also reported that there was a positive effect on examination scores of PBL integrated with e-learning compared to traditional PBL, even though the difference is not statistically significant. They stated that the improvement in examination scores maybe because students' motivation is higher when they are using computers and the Internet. They assumed that maybe the use of computers and the Internet is preferred by students. The Internet provides opportunities for students to learn across time and location. Moreover, Yu et al. [33] showed similar finding that the use of blended learning, where PBL is integrated with e-learning gave positive impact on student achievement. Similar to this finding, Gunduz et al. [34] conducted a study aimed at investigating the effectiveness of problem-based online learning and found that the use of web-based on PBL gave a positive effect on learning.

The positive effect of ICTs support in TTM is found not significant in this pilot study. This phenomenon is also found by Alqahtani [35] who concluded that, despite the result of students' examination scores being higher from Blended Learning (TTM with ICTs support) than TTM, the difference of the results from both methods was not significant. In Blended Learning, the terminology of e-learning was used here instead of ICTs, although the meaning is the same where materials were given from and through the Internet. It is stated that the use of e-learning will give some advantages, such as flexibility and cost-effectiveness, although it also brings several disadvantages, such as lack of clarification and undeveloped communication skills.

Through further discussion with ten students in this pilot study, the use of ICTs was strongly suggested as the students can learn the course materials from the uploaded lecture and reading materials prior to classes and group discussions. Moreover, the students are able to search for more materials or other information related to the lecture topics on the Internet. In term-time, it is suggested that online group discussions are performed in several small groups of about ten students. This is to ensure that all students can be actively involved in the discussion.

The discussion with the students also reveals that they prefer the implementation of TTM with ICTs support to the PBL method with ICTs support. The main reason is that in the implementation of TTM with ICTs support, they are provided with certain lecture slides and other course-related materials, whereas in the PBL method with ICTs support, they are only provided with some course-related materials without lecture slides. The support of ICTs is considered important in developing their self-study skills by searching further related information on the Internet. Moreover, the students find that, in order to have a successful PBL method, a specific room environment is required, i.e., a small and noise-proof discussion room equipped with air conditioning, especially in a warm tropical climate. Therefore, for better implementation of these methods of learning, particular evaluation, especially from the students' perspective, should be taken into consideration. Stavropoulou et al. [36] state that evaluation in nursing education can be conducted in qualitative or quantitative method. A combination between those two methods is considered the best approach for program

evaluation. Through this combination evaluation method, agreement between the two is looking forward as well as finding consistency. Other than this, evaluation on nursing students' computer skills is important as well. A study that explored nursing students' computer skills have indicated that one third of student did not have PC at home, two third of students were not skill full in internet usage and only approximate 10% used electronic databases. Moreover, this study implies that there was a lack of students' IT competencies. This study suggest the need of enhancing IT competencies amongst nursing students, through improving the curriculum. It is also suggested to consider basic requirement for technology competency at school admission [37].

In term of student size in this pilot study, each group consists of 12-16 students. A bit larger that it is suggested. It might hinder the quality of tutorial process. Barret [16] proposes group of eight or less. Small team is better for solving the problem given. If the group is too large, traditional teaching method is preferred.

The effectiveness of a learning method should be evaluated by level of knowledge, clinical skills, laboratory skills, and other criteria. However, this pilot study evaluates the effectiveness of several learning methods based only on students' knowledge level, through examination scores.

## Conclusion

Several conclusions can be drawn from this pilot study. First, without the support of a ICTs application, this pilot study has shown that the implementation of TTM resulted in better students' examination scores than the PBL method. Second, the application of ICTs in general increases students' examination scores from both TTM and PBL methods. However, the ICTs application only gives a significant improvement when used with the PBL method. Moreover, the support of a ICTs application also gives significant improvement if the PBL method is combined with TTM. This pilot study also found that the PBL method with the support of a ICTs application gave the highest result of students' examination scores of all the evaluated methods.

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## Contributions

Study design: Juniar Ernawaty and Astried Sujono, Data collection: Juniar Ernawaty, Manuscript writing: Juniar Ernawaty.

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