Digitizing Project-Based Learning in engineering education

L Latifah*, J Maknun and R Mardiana
Department of Architectural Engineering Education, Universitas Pendidikan Indonesia, Dr. Setiabudhi No. 207, Kota Bandung, Indonesia

*linalhanan@gmail.com

Abstract. Students tend to be not explorative in solving their assignment. Improper learning system is one of several factors that probably be the cause of this problem. This research aims to analyze students’ problem solving abilities through the implementation of Project-Based Learning (PjBL) on Construction and Building Utilities subject. The research design is Quasi-Experimental Design with the type of Two-Group Posttest Only research. The population of this research is the students of XI DPIB in SMKN 9 Garut 2018/2019. The experimental class students use PjBL while the control class students use expository learning. Data analysis is obtained from students’ problem solving abilities test and observation results. The students’ problem solving abilities scores are calculated based on four steps of Polya’s problem solving theory, first is understanding the problem, second is planning how to solve the problem, third is calculating, and fourth is checking the result. The analysis result shows that the experimental class students have better problem solving abilities than the control class students. In addition, the experimental class students are more active and communicative in the class. According to problem solving ability test and observation results, PjBL is quite effective to be implemented on Construction and Building Utilities subject.

1. Introduction
Based on Indonesian Law No. 20 of 2003 concerning the national education system, vocational high schools are education units at the level of secondary education that aim to prepare students to be able to work in certain fields [1]. One of vocational high school which is held by the government of Indonesia is SMKN 9 Garut. This school has several competencies that are adapted to the needs of the existing workforce, one of the competencies is DPIB/Modelling Design and Building Information. In general, students of DPIB learn about building construction, road and bridge construction, land measurements, construction drawings both manually and using computer applications, interior and exterior design, estimate construction cost, making development reports, and others.

In order to master these competencies, the learning process should be adjusted to the characteristics of competencies and levels of education. This was explained in Indonesian Minister of Education Regulation No. 65 of 2013 concerning the standard of secondary education process, that the learning model, methods, media, and resources which are implemented in 2013 curriculum have to be adjusted to the characteristics of students and subjects [2]. However, based on the observations of researchers, DPIB students tend to be passive and not explorative in finishing their assignments in Construction and Building Utilities subject. Students get grades below the KKM/Minimal Completeness Criteria, the students’ construction drawing assignments are not in accordance with the rules, and the completion of assignments are not on target.
The factors that probably be the cause of these problems are students have low motivation, inadequate studio facilities and infrastructure, teachers haven’t found an effective way to deliver the subject matter, as well as the improper learning systems. According to the RPP/Learning Implementation Plan of Construction and Building Utilities subjects, the learning model that is used by teachers doesn’t change in years. Teachers use expository learning model, so the teacher conveys material verbally and plays a very dominant role (teacher centered approach). It considers provides less opportunities for the student to develop their problem solving skill. This condition indicates that expository learning model is irrelevant and it’s the factor that has a major influence on the low student learning outcomes. Therefore, in this study the author tries to focus on the learning model that is used by the teacher.

One of the contextual learning that is assessed to be able to increase students’ activities is the Project-Based Learning/PjBL model. Sears and Hersh define contextual learning as learning that enables students to learn to use their academic understanding and abilities in various contexts inside or outside school to solve real-world or simulative problems, both alone and in groups [3]. Besides being able to improve understanding, the application of PjBL learning models can also affect students' problem solving abilities.

Project assignments can be used as alternative learning that provides context for students' daily lives and trains students to develop problem solving skills. One of the issues that can be used as the project topic in Construction and Building Utilities subject is the issue of sanitation problems in Garut. Based on the health profile of the Ministry of Health in 2014, Garut was ranked among the five lowest cities in access to sanitation facilities [4]. Seeing this phenomenon, one solution that can be done is to provide communal septic tank facilities, especially in dense residential areas in Garut to minimize the spread of disease.

In the process of providing communal septic tanks, of course, a careful planning is needed. Vocational High School as a secondary education level, especially the competencies of DPIB can also prepare their students to be able to contribute in providing communal septic tank system planning solutions. By presenting this problem as project assignments in Construction and Building Utilities subject, students of DPIB can also learn and more aware about this problem. Through the problem solving process during this project, students are expected to be more motivated, active, and understand the material itself. Learning will be more fun, more challenging, and more meaningful because students are involved in the process of finding solutions to problems that are around them in the real world.

2. Methods
This research is a quantitative study using experimental methods. The research design is Quasi-Experimental Design with the type of Two Group Posttest Only research [5]. The population of this research is the students of XI DPIB in SMKN 9 Garut. The students of XI DPIB 2 are samples of experimental class who use PjBL while the students of XI DPIB 1 are samples of control class who use expository learning. Data analysis is obtained from students’ problem solving abilities (PSA) test and observation results. The students’ PSA test scores are calculated based on four steps of Polya’s problem solving theory, namely understanding the problem, planning problem solving, calculating, and rechecking the results [6]. The data analysis technique is done through normality test, homogeneity test, hypothesis test, and PSA analysis by calculating student PSA test score in terms of four steps of problem solving based on Polya's theory.

3. Results and discussion
After implementing PjBL and expository learning model in XI DPIB class, students then take the PSA test. Students' answers on the PSA test were then analyzed based on Polya's problem solving steps. Each problem solving step has a different value that is determined based on the level of difficulty. The PSA percentage of each class is categorized as follows:
Table 1. Class PSA rating.

| Category | The Class PSA Percentage |
|----------|--------------------------|
| Good     | ≥ 80%                    |
| Fair     | 51% - 79%                |
| Poor     | ≤ 50%                    |

After analyzing based on Polya's theory, then students’ PSA are categorized based on PSA categorization according to Samo [7] as follows:

Table 2. PSA categorization.

| Category | Description |
|----------|-------------|
| Good     | Minimum three good categories at problem solving step |
| Fair     | Minimum three fair categories at problem solving step |
| Poor     | At least three poor categories at problem solving step |

The level of effectiveness of the learning model can be measured according to the following table:

Table 3. The level of effectiveness of learning model.

| Category | Level of Effectiveness |
|----------|------------------------|
| Good     | Effective              |
| Fair     | Quite Effective        |
| Poor     | Less Effective         |

3.1. The experimental class students’ Problem Solving Abilities (PSA)

After implementing PjBL and doing PSA test, the experimental class students’ PSA score as follows:

Table 4. Experimental class students’ problem solving abilities category.

| Class        | Question No. | Steps of Problem Solving |
|--------------|--------------|---------------------------|
|              |              | 1 | 2 | 3 | 4 |
| Experimental | 2            | 79% | 25% | 88% | 35% |
|              | 3            | 85% | 85% | 86% | 53% |
| Average PSA percentage | 81% | 55% | 87% | 44% |
| PSA Category | E | S | E | B |
| Conclusion   | Quite Effective |

Based on Table 4, it is known that in question number 2 regarding the calculation of the slope of the pipe, the experimental class students are good in the first step (understanding the problem), fair in the second step (planning problem solving), good in the third step (doing the calculation), and poor in the fourth step (re-checking the results). Whereas in question number 3 regarding the plan for communal septic tank, the experimental class students are good in the first, second, and third step, and fair in the fourth step. Overall, it can be concluded that the PSA of the experimental class students is included in the fair category so that the PjBL learning model is quite effective to be applied on Construction and Building Utilities subject.

3.2. The control class students’ Problem Solving Abilities (PSA)

After implementing expository learning model and doing PSA test, the control class students’ PSA score as follows:
Table 5. Control class students’ problem solving abilities category.

| Class | Question No. | Steps of Problem Solving | 1 | 2 | 3 | 4 |
|-------|--------------|--------------------------|---|---|---|---|
| Control | 2 | | 59% | 59% | 74% | 36% |
| | 3 | | 52% | 70% | 66% | 36% |
| Average PSA percentage | | | 56% | 47% | 70% | 36% |
| PSA Category | | | S | B | S | B |
| Conclusion | | | Less Effective |

Based on Table 5, it is known that in question number 2 regarding the calculation of the slope of the pipe, the control class students are fair in the first step (understanding the problem), poor in the second step (planning problem solving), fair in the third step (doing the calculations), and poor in the fourth step (re-checking the results). Whereas in question number 3 regarding the plan for the communal septic tank papa lane, the control class students are fair in the first, second, third, as well as poor in the fourth step. Overall, it can be concluded that the expository learning model is less effective to be applied on Construction and Building Utilities subject.

There is an increase and decrease in the results of student answers from question number 2 to question number 3 both in the experimental class and the control class. A significant increase occurred in the second step, namely planning problem solving. In question number 2, students didn’t explain the formula to calculate the slope of the pipe, while in question number 3, students succeed in expressing a description of the plan to complete the communal septic tank pipeline. This condition shows that students are actually able to express the problem solving plan, but they aren’t accustomed expressing the solution plan in the form of a mathematical formula that will be used to answer the question.

The decrease of PSA score in the experimental class occurs in the third step, but the percentage is ≥ 80% so that the experimental class students can still be said to have good abilities in carrying out problem solving. Whereas the decrease in PSA score in the control class occurs in the first and third step, where the percentage of PSA shows that the PSA of the control class students is in fair category in understanding the problem and implementing problem solving.

3.3. Comparison of experimental class and control class students’ Problem Solving Abilities (PSA)

The difference in the PSA test results of the experimental class and control class students are as follows:

Table 6. The differences in the PSA test results of experimental and control class students.

| Description | Class |
|-------------|-------|
| Average PSA Test | Control | Experimental |
| Lowest Score | 66.95 | 75.67 |
| Highest Score | 85 | 92 |
| Under Minimal Completeness Criteria | 14 | 8 |
| Above Minimal Completeness Criteria | 5 | 10 |

Based on Table 6, the average score of PSA test for experimental class students who use the PjBL is higher than the control class students who use expository learning model. This shows that PjBL has a positive impact on PSA of the experimental class students. The experimental class students are also more enthusiastic and actively participating in the class compared to the control class students.

The lowest score of the PSA test in the control class is 42 while the experimental class is 52. Based on the results of the analysis of students’ answers accordance to the theory of Polya problem solving steps, the results are obtained that the two students don’t understand the questions. Whereas, this step is
the most crucial step in solving a problem. If the student doesn’t understand the questions, it is certain that the student won’t be able to answer the questions correctly.

The highest PSA test score in the control class is 85 while the experimental class is 92. After analyzing the students' answers to the theory of Polya problem solving steps, the results are obtained that both students are able to understand the questions, make problem solving plan, carry out calculations, and provide answer conclusions well. This condition shows that in order to be able to answer the questions correctly, students must be able to master the four steps of problem solving in accordance with Polya's theory because these steps are integrated.

The results of the PSA test are analyzed through normality test, homogeneity test and hypothesis test. The parametric test results with an accuracy level of 95% can be seen in the following table:

| The Statistic Elements | Class          |          |          |
|------------------------|----------------|----------|----------|
|                        | Control        | Experimental |
| N                      | 19             | 18       |
| dk                     | 3              | 4        |
| $X^2_{\text{count}}$  | -30,348        | -19,667  |
| $X^2_{\text{table}}$ | 7,815          | 9,488    |
| SD                     | 12,29          | 11,83    |
| Variant ($S^2$)       | 151,044        | 139,949  |
| $F_{\text{count}}$    | 0,927          |          |
| $F_{\text{table}}$    | 9,12           |          |

Based on Table 7, the results show that the control class and experimental class data are normally distributed and homogeneous. Furthermore, the results of hypothesis testing using the pooled variant t-test show that Ho is rejected and Ha is accepted, or "There is a difference in the problem solving abilities of students who use the Project-Based Learning and students who use expository learning models".

Several previous researchers have tried to analyze the effect of the PjBL on students' problem solving abilities. After applying the PjBL to the experimental class and the conventional learning model to the control class on the subject of dynamic fluid, the results were obtained that the problem solving ability of the experimental class who use PjBL was more improved than the control class who use the conventional learning model [8].

The PjBL learning model can also influence the motivation and problem solving abilities of vocational students in Taiwan who initially had low learning abilities and motivation, as well as didn’t have problem solving experience [9]. In addition, after applying the PjBL to mathematics subjects, the results obtained that the average value of the problem solving ability of the experimental class who use the PjBL is higher than the control class who use the conventional learning model. Learning in the experimental class is also better because students exchange ideas, complement each other, and solve problem together [10].

Some relevant research results indicate that there are differences in problem solving abilities between students who use the PjB and students who use expository learning models. Likewise, with this research, after reviewing students' PSA test answers based on Polya's problem solving theory, the problem solving abilities of experimental class students who use PjBL are better than the control class students who use expository learning model.

4. Conclusion

After implementing the PjBL in Construction and Building Utilities subject in class XI DPIB 2 at SMK Negeri 9 Garut, the results of observations indicate that the PjBL has a positive impact on their problem solving ability. The experimental class students who use the PjBL are more active in asking questions, expressing opinions, and listening to the opinions of others. Overall, the experimental class students’ PSA is in the good category. Meanwhile, after implementing the expository learning model in class of
XI DPIB 1, students are less active in asking or answering questions related to the subject matter. This condition affects students’ PSA test results. Overall, the control class students’ PSA is in the fair category.

Based on the results of the PSA test, the PSA score of the experimental class students was higher than the control class students. This is supported by the results of hypothesis test which shows that there are differences of problem solving abilities of the students who use the PjBL and the students who use expository learning model in Construction and Building Utilities subject. Therefore, based on the responses of the experimental class and control class students, the results of the PSA test, as well as the results of the hypothesis test, it can be concluded that learning using the PjBL is quite effective to be applied to the Construction and Building Utilities subjects.

References

[1] Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional. 8 Juli 2003. Lembaran Negara Republik Indonesia Tahun 2003 Nomor 4301 (Jakarta)

[2] Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 65 Tahun 2013 Tentang Standar Proses Pendidikan Dasar dan Menengah. 4 Juni 2013. Berita Negara Republik Indonesia Tahun 2013 (Jakarta)

[3] Kamdi W 2010 Implementasi Project-Based Learning di Sekolah Menengah Kejuruan Jurnal Pendidikan dan Pembelajaran 17(1) 98-110

[4] Kompasiana 2016 Rendahnya Penggunaan Jamban Sehat di Desa Sukamaju Kecamatan Talegong, Garut [Online] Retrieved from: https://www.kompasiana.com/fascal/58503172597b61b57013e11c/rendahnya-penggunaan-jamban-sehat-di-desa-sukamaju-kecamatan-talegong-garut-jawa-barat

[5] Mulyatiningsih E 2014 Metode Penelitian Terapan Bidang Pendidikan (Bandung: Alfabeta)

[6] Syaharuddin 2016 Deskripsi Kemampuan Pemecahan Masalah Matematika dalam Hubungannya dengan Pemahaman Konsep Ditinjau dari Gaya Belajar Siswa Kelas VIII SMPN 4 Binamu Kabupaten Jeneponto (Makassar: Universitas Negeri Makassar)

[7] Samo D D 2017 Kemampuan Pemecahan Masalah Mahasiswa Tahun Pertama pada Masalah Geometri Konteks Budaya Jurnal Riset Pendidikan Matematika 4(2) 141-152

[8] Makrufi A, Hidayat A and Muhardjito 2018 Pengaruh Model Pembelajaran Berbasis Proyek terhadap Kemampuan Pemecahan Masalah Pokok Bahasan Fluida Dinamis Jurnal Pendidikan 3 (7) 878-881

[9] Chiang C L and Lee H 2016 The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students International Journal of Information and Education Technology 6(9) 709-712

[10] Nurfitriyanti M 2016 Model Pembelajaran Project Based Learning Terhadap Kemampuan Pemecahan Masalah Matematika Jurnal Formatif 6 (2) 149-160