Borneo Engineering & Advanced Multidisciplinary International Journal (BEAM)
Volume 3, Issue 1, May 2024, Pages 54-59

System Analysis and Design Assessment: Adapting 15 Steps of PBL in Programming Education

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Full Paper

Article history
Received
20 February 2024
Received in revised form
13 May 2024
Accepted
14 May 2024
Published online
15 May 2024

Abstract

This study examined students' perception on the initial implementation of Problem Based Learning (PBL) approach in solving problems of Laboratory Worksheet Activity (LWA). The problem-solving covered Topic 2 (Preliminary Analysis) in the System Analysis and Design (SAD course). The implementation of PBL was applied to students who were undergoing System Analysis and Design courses. Fifteen steps PBL in programming education were applied in solving problems of Laboratory Worksheet Activity for Topic 2. Qualitative and Quantitative techniques were employed using descriptive analysis and thematic analysis. The problem-solving session was carried out by having students work in small groups under the guidance of facilitators. Findings showed that students deem the PBL approach to be unfamiliar and it takes time to get started. Despite rejection by a few students, PBL mainly, was acknowledged as beneficial in terms of the solving problem process systematically as well as encouraging collaborative learning. Implications from this study found that even though students accepted PBL positively, urge, effort, and scaffolding from the instructors were essential. Predominantly, students were satisfied with the implementation of PBL in completing LWA. It was suggested that PBL settings to be implemented throughout the semester to investigate the implementation thoroughly. Implications for practice that may be implemented in future are discussed.

Keywords: - Problem based learning, system analysis and design, PBL

1. Introduction

Problem-based Learning (PBL) has gained recognition as a powerful method for fostering problem-solving skills, collaborative teamwork, and high-order critical thinking. Across various disciplines, including Computer Science and System Analysis and Design (SA&D), educational institutions are increasingly embracing PBL (Aspy & Aspy, 2022; Balykbaeva et al., 2021; Yew & Goh, 2016; Marti et al., 2006 and Bentley et al., 2002). PBL's effectiveness has been observed across different educational settings, from the macro to micro levels (Chen et al., 2020 and Tan, 2003). Fundamentally, the PBL infusion of micro level is more appropriate to be implemented in course level as a preparatory step prior to entirely applying it in SAD course. The implementation was distinctly evaluated in terms of point of readiness as well as improvisation that may be required to acquire a fruitful outcome. This study described students' experience on PBL implementation for LWA 2 in System Analysis and Design course. The purpose of this study is twofold: to assess students' readiness for PBL and to propose enhancements for future implementations. Understanding students' readiness towards PBL is pivotal as it directly influences the success of PBL initiatives and student learning outcomes. Moreover, it sheds light on the challenges and opportunities associated with PBL adoption in SA&D education. In the past, PBL has been introduced in various forms and durations. However, the specifics of previous implementations and their outcomes are essential to inform the need for improvement. By examining

existing implementations, we can identify areas for refinement and better understand the factors contributing to the success or challenges of PBL in SA&D courses.

2. Literature Review

Systems Analysis and Design (SA&D) is a course that emphasizes the phases involved in the System Development Life Cycle (SDLC) (Shelly & Rosenblatt 2012 and Surendren et al., 2005). In SDLC basically, problem identification must be investigated during an earlier phase and an effective solution should be proposed. Team members must apply good communication skills throughout the processes (Gould, 2016). On that point, the Teaching and Learning (T&L) method that is suitable to be adopted to gain learning outcomes such as PBL should be applied.

PBL is a T&L method that triggers the learning process by solving real world problems (Ikawati, 2020). Students are expected to obtain learning outcomes in the process of problem-solving. The process can yield positive critical thinking ability impact, problem-solving skills, and knowledge (Zamroni et al., 2020 and Yusof et al., 2015). In PBL, students can assess what they know and determine what they need to know. Students are also required to compile information and collaborate in evaluating ideas pertinent to solution and direct it to fact searching activity. In the meantime, instructors play the role as facilitator to scaffold learning activity while students lead the learning process in a team (Hmelo-Silver, 2004; Savery 2015; Scott 2014 and De Graaf & Kolmos 2003).

PBL is implemented widely in engineering (Hadibarata et al., 2023) and computer science fields (Hutchins & Biswas, 2024) throughout various levels including course, cross-course, curriculum, and projects. The implementation requires specific settings according to the respective level (Chen et al., 2020). To practice PBL, careful and thorough preparation is required. Therefore, the implementation of PBL should be done in stages to get feedback from the parties involved for improvement. The initial setting of PBL can be set up with course level. At course level, PBL elements were instilled in the problem-solving case. On the other hand, PBL units were implemented to improve students' understanding and knowledge application (Williams, 2011). The adoption of PBL in a course contributes to knowledge management and practical skills (Dong and Guo 2014 and Chaparro-Pelaez et al., 2013). Moreover, it requires minimal coordination from educators. PBL can be infused in a curriculum based on three approaches: mega, macro, and micro levels. Micro levels are more suitable to be implied at course level (Tan, 2003).

Together with PBL setting and strategies, the procedure of problem solving has been emphasized as well. Originally, seven steps in PBL problem solving procedure were introduced in medical education (Schmidt, 1983). The seven steps of PBL are widely adopted by practitioners across various institutions and disciplines. However, effective adaptation of PBL in specific fields, such as programming courses (Aires et al., 2023), often requires modifications. In programming, where tasks involve writing code to solve problems, create simulations, or develop software applications, these modifications become necessary. These activities are aimed at fostering problem-solving skills, logical thinking, and creativity among students (Sulaiman et al., 2023). Consequently, to accommodate the unique demands of such disciplines, the original seven-step PBL process has been expanded to include 15 steps (Bawamohiddin & Razali, 2017). The 15 steps in programming education were performed in three meetings. Steps in the first meeting involve 1) Form a group and determine role of group members; 2) Distributing problem; 3) Review problem; 4) Identify problem; 5) Brainstorming; 6) Sketching explanatory model; and 7) Summarize learning issues. Then, students will engage in a self-learning session which involves steps 8) Gather information individually; 9) Design program; and 10) Prepare a summarized report. Next, in the second meeting, students will conduct steps 11) Synthesize information of problem needs and program; 12) Develop program; 13) Completing technical report. Eventually in the third meeting, steps 14) Presenting program and 15) reflecting will be executed by students to complete the solution.

Notwithstanding guidelines on setting or problem-solving procedures already discussed in previous studies, the implementation of PBL is exacting to begin with. It requires both teachers and students to transfer from the conventional learning approach to PBL. It affects students' motivation and performance especially to work in a team (McQuade et al., 2018). Students also are expected to be students-centric, that needs students to enforce higher learning ability. The self-learning process has been pointed out as a challenging process (Henry et al., 2012; Hu, Ortiz and Sriraman, 2014 and Lutsenko, 2018). Therefore, PBL must be implemented gradually in stages and requires post implementation evaluation. At this point, students' perception and attainment must be investigated. According to these representations, the paper strives to report the results on the micro level of PBL implementation in the System Analysis and Design course using the 15 steps of PBL in programming education.

3. Result and Analysis

This study used quantitative and qualitative techniques. Both quantitative and qualitative analyses were employed to investigate students' perception on PBL implementation in assessments. The main data included questionnaires. The themes of the outlined results were generated by the questions in this questionnaire. The data were first collected and analyzed (Patton, 1990). The survey was carried out after applying PBL strategy.

Participants. The goal of this study is to probe students' perception on PBL implementation during SAD, DDT program, in June 2020. The participants were 17 students who are taking the course ranging from age 19 to 20 years.

Research Design. The research design was adapted from the framework of PBL in programming education (Bawamohiddin & Razali, 2017). The adaptation focused on 15 steps of problem-solving activities involving students and facilitators. A micro-level approach of PBL

can be applied as a methodology in a course because it is more suitable to be enacted for certain topics within a certain period. This is because a micro-level approach of PBL requires minimum commitment and resources. Consequently, this approach is particularly suggested for PBL pioneer implementation (Tan, 2003 and Yusof et al., 2005).

The research design was to halve two sessions of teaching methods. The first session implemented traditional teaching methods, whereas the second session adopted PBL strategy in problem solving of Lab Work Sheet (LWA). The study adopted 15 steps of PBL for programming education, to solve LWA 2 in SAD coursework assessment. The SAD course consists of 4 hours per week encompassing two hours lecture for the first period and 2 hours practical for the second period. Two weeks were allocated to complete the T&L of Topic 2. Therefore, the implementation of the PBL approach was arranged in two weeks corresponding to the T&L planner. The arrangement of T&L started in the two hours in the first period in Week 1. Class introduction and explanation of course outline was delivered and then continued with lecture of Topic 1. Subsequently, exercise related to Topic 1 was distributed and completed in the following class session in the same week. The exercise was given to strengthen students' knowledge on Topic 1. Next, LWA 1 was distributed in the following week. Since LWA is group work, group formation was required, and students organized their solution before submitting and presenting it in the second period in the same week. The LWA 1 answering process took place in a laboratory with facilitator assistance. Overall, the LWA 1 completion took two weeks. Next, PBL method was implemented in the third week of the semester. The procedure of implementation is described precisely in the next section.

The Procedure of Implementation. PBL strategy was initiated in the third week of the semester. The entire process took two weeks to complete. Overall, the implementation structure entailed three face-to-face meetings and one self-learning session. The problem-solving strategy adapted the 15 steps of PBL in programming education. The reason for applying the 15 steps of PBL in programming to solve problems in SAD assessment is because of the problem-solving features in a programming course corresponding to SAD course. The Association for Computing Machinery (ACM) and IEEE Computing Society Joint Task Curricular (2014) emphasizes students' skills on dealing with problem-solving tasks. The SA&D course emphasizes such topics as systems development life cycle, communication with both users and developers, and a variety of standard tools, techniques, and heuristics relevant in preparing requirements and design specifications. The knowledge elements of the course reflect the principles and techniques used in the analysis and design aspects of software development. Specifically, in this course the students apply the techniques and tools of the procedure centric structured methodology for producing the intermediary system artifacts (from inception to design) of software development.

Table 1. Comparison of the traditional and 15 steps of PBL in programming education

The traditional teaching method	The 15 steps PBL adaptation
First Meeting	**First Meeting**
I. Class introduction and explanation of the course outline using powerpoint, (First Meeting)	I. Class introduction (First Meeting)
II. Explanation about Topic 1	II. Explanation of PBL planner III. Distribute PBL template. IV. Initiate PBL step 1-7 during class facilitate by facilitator 1) Form a group and determine roles of members 2) Distributing LWA 3) Review LWA 4) Identify problem 5) Brainstorming 6) Sketching explanatory model 7) Summarize learning issues
Second Meeting	**Self-Learning (One week)**
III. Perform exercise to comprehend knowledge of Topic 1 during lab session (2 hours) with Facilitator guidance.	8) Gather information 9) Design program 10) Prepare a summarize report
Third Meeting	**Second Meeting**
V. Distribute LWA 1 and completion activity with facilitator guidance (2 hours).	11) Synthesize information of problem needs and program (second meeting) 12) Complete answer 13) Write technical report
Fourth Meeting	**Third Meeting**
VI. Presentation of LWA 1 answer VII. Reflection (second week - practical session - 2 hours)	14) Present 15) Reflection

However, the programming development step was not relevant. Therefore, modifications were made in steps 11 and 12 by replacing the programming activity with SAD related solutions. Prior to PBL strategy implementation, facilitators have explained about the expected learning outcomes as well as the PBL planning. PBL template was used to scaffold students to complete the whole process. PBL template contains information of learning outcome to achieve, problem, probing questions to encourage students to initiate the PBL process (what information you know, what information you need to know, why is your answer reasonable) and reflection. The process mechanism is as follows:

i. In the first meeting, PBL template and LWA were distributed to the students. Students initiated the PBL steps 1 – 7 with facilitator guidance. Students filled in the required information (what information do you know, what information you need to know, why is your answer reasonable). The facilitator directed students to answer questions in the template to address solutions to the problem.

ii. After that, students conducted self-learning sessions individually. Students were advised to look up information in SAD e-books, online information, and any appropriate sources. Students were required to organize searched information.
iii. In the second meeting, each student presented the searched information and synthesized it in the group to produce possible solutions related to the problem. Students developed answers using any software and wrote technical reports.
iv. Finally, in the third meeting students presented the answer and facilitator commented and gave feedback. Then the session was closed with reflection.

Data Collection. A descriptive, online survey was developed and distributed after the implementation of PBL strategy to the 17 students. The questionnaire was designed according to the purpose of the study, including satisfaction of PBL adoption in problem solving. The survey contained both quantitative and qualitative questions. The questions are as follow:

1. The PBL method can stimulate my desire to learn.
2. The PBL method allows me to understand learning outcomes better.
3. The PBL process can enhance problem-solving strategy.
4. I am able to produce a solution using the PBL method effectively.
5. Overall, I am very satisfied with PBL.
6. What is your opinion/suggestion of PBL?

4. Discussion

The analyzed data described students' perception on PBL approach towards problem-solving activity. Overall, students were positive to the PBL approach in solving laboratory worksheet activity no. 2 (Table 2). Nevertheless, there were also students who found it useless and a hassle to be adopted. Students perceived that PBL approach stimulated their learning desire (70.6%), while 11.8% of students were undecided and the rest (11.8%) disagreed with the approach. Data analysis also positively concurs that PBL approach helped them understand learning outcomes better (70.6%), compared to 17.6% undecided students on the item and 11.8% students disagreed. Students were also perceived to enhance their problem-solving strategy (76.5%). Data analysis further indicated positive results on PBL as it was able to produce solutions effectively (76.5%). Lastly, data revealed that students were content with PBL implementation (64.7%). However, 23.5% students were unsure, while 5.9% students disputed that they were optimistic on PBL implementation.

Qualitative evidence confirmed this positive finding when respondents made comments such as “PBL is a useful learning approach”, “I like PBL in my learning because I understand what to do. Time not wasted”, “Apart from the traditional approach, I find it helpful. For problem-solving, it's kind of a systematic way.” Students also commented on fruitful cooperation in group work “This PBL style is something that I like. Problem-solving activity can be structured. Most importantly, all group members participated very well”, “I like to use PBL to solve problems. The problem-solving process is very orderly, in stages. All students had to participate. There are no free riders in the group”. Some feedback also stated that it was hard to pursue PBL initially, yet they adapted to it ultimately. This was supported by comments as follows, “I think it’s hard at first to use PBL… But gradually we can accept it. It sorts of forced one to think harder”, “Need more time and practice to get used to this approach”, “Hard to adapt to it at first, but I can do it finally” Even so, negative remarks were also rendered. Some responses depicted students rejecting the idea of implementing PBL in the learning process such as “I don’t like PBL. Tired of thinking too much”, “I struggled with thinking a lot”. The negative comments reflected that students were reluctant to move out of their comfort zone and wanted to stick with conventional approaches.

Table 2. Students' perception on PBL approach towards problem-solving activity

	Strongly agree		Agree		Undecided		Disagree		Strongly disagree	
	n	%	n	%	n	%	n	%	n	%
The PBL method can stimulate my desire to learn.	2	11.8	10	58.8	3	17.6	2	11.8	0	0
The PBL method allows me to understand learning outcomes better.	4	23.5	8	47.1	3	17.6	2	11.8	-	-
The PBL process can enhance problem-solving strategy.	5	29.4	8	47.1	2	11.8	2	11.8	-	-
I am able to produce a solution by using PBL method effectively.	6	35.3	7	41.2	2	11.8	2	11.8	-	-
Overall, I am very satisfied with PBL.	7	41.2	4	23.5	4	23.5	1	5.9	1	5.9

PBL needs students to participate actively in learning strategies and practice self-directed learning. Initially, students reluctantly coped with the transition from traditional approach to active critical thinkers. The challenge started when the PBL approach directed students to take control and be active in their learning process. No lecture was delivered before the problem-solving process took place. In addition, the learning process was driven by solving problems that were unable to be defined in the first meeting. The problem-solving process was tough for them. However, most of the students found PBL as a useful and systematic way in T&L. Also, this approach triggered critical thinking and polished problem solving and promoted creative thinking. Therefore, it is undeniable that PBL does offer a beneficial impact to the students' learning process. As the 15 steps PBL implementation was worth

practicing for the SAD course, thorough implementation of PBL in programming education that is adapted to the SAD course should be implemented to elucidate on the perspective of students, lecturer, and management. Therefore, the implementation of PBL should be conducted throughout the semester to assess the entire process. Readiness to implement the approach requires time and meticulous preparation before making it as one of the main T&L methods for the course. Instructors should plan the implementation concisely before applying the method throughout the semester to gain fruitful outcomes. The planning should take a few important elements into account such as syllabus content, scaffolding techniques or tools, staff upskilling, and the most crucial part is the problem creation because the problem is the heart of PBL.

5. Conclusion

The paper intends to manifest students' experience regarding the implementation of the 15 steps of PBL in solving problems in the SAD course. Students positively perceived PBL in terms of upgrading their problem solving and critical thinking skills. In addition, PBL also was acknowledged as promoting collaboration in teamwork. Aside from enhancing the mentioned skills, PBL also helped students to organize the problem-solving process in a more systematic way. A multi-dimension commitment from various stakeholders is required to ensure the success of the PBL implementation in the SAD course, particularly from students and facilitators.

References

Aires, J. P., Aires, S. B. K., Pereira, M. J., & Alves, L. M. (2023). Using the methodology problem-based learning to teaching programming to freshman students. *International Journal of Information and Education Technology*, *13*(3), 448-455.

Aspy, D. N., & Aspy, C. B. (2022). Problem Based Learning. *Journal of Invitational Theory and Practice*, *2*(2), 69–77. http://dx.doi.org/10.26522/jitp.v2i2.3759.

Balykbaeva, G. T., Tapalova, A. S., Abyzbekova, G. M., Espenbetova, Sh O., & Arynova, K. Sh. (2021). Inorganic Chemistry Problem-Based Learning. *Bulletin Of the Korkyt Ata Kyzylorda University*, *58*(3), 63–73.

Bawamohiddin, A. B., & Razali, R. (2017). Problem-based learning for programming education. *Learning*, *13*, 15.

Bentley, J., Sandy, G., & Lowry, G. (2002). Problem-based learning in information systems analysis and design. In *Challenges of information technology education in the 21st century* (pp. 100-123). IGI Global.

Chaparro-Peláez, J., Iglesias-Pradas, S., Pascual-Miguel, F. J., & Hernández-García, Á. (2013). Factors affecting perceived learning of engineering students in problem based learning supported by business simulation. *Interactive Learning Environments*, *21*(3), 244-262.

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *European Journal of Engineering Education*, *46*(1), 90-115.

De Graaf, E., & Kolmos, A. (2003). Characteristics of problem-based learning. *International journal of engineering education*, *19*(5), 657-662.

Dong, J., & Guo, H. (2014, June). Effective Course Redesign Strategies to Integrate Collaborative PBL in Senior Computer Engineering/Computer Science Courses. In *2014 ASEE Annual Conference & Exposition* (pp. 24-454).

Gould, H. (2016). Systems analysis and design.

Hadibarata, T., Hidayat, T., & Kwabena, J. (2023). Problem Based Learning in Engineering Course in Malaysia. *Acta Pedagogia Asiana*, *2*(2), 95-105. https://doi.org/10.53623/apga.v2i2.234.

Henry, H. R., Tawfik, A. A., Jonassen, D. H., Winholtz, R. A., & Khanna, S. (2012). "I know this is supposed to be more like the real world, but...": student perceptions of a PBL implementation in an undergraduate materials science course. *Interdisciplinary Journal of Problem-based Learning*, *6*(1), 43-81.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational psychology review*, *16*, 235-266.

Hu, J., Martinez Ortiz, A., & Sriraman, V. (2014, June). Implementing PBL in a Concrete Construction Course. American Society for Engineering Education.

Hutchins, N. M., & Biswas, G. (2024). Co-designing teacher support technology for problem-based learning in middle school science. *British Journal of Educational Technology*, *55*(3), 802-822.

Ikawati, J. (2020). Subject Specific Pedagogy Design based on Problem-based Learning to Stimulate Problem Solving Ability. *Journal of Advanced Research in Dynamical and Control Systems*, *12*(SP7), 1875–82.

Kuo, H. C., Tseng, Y. C., & Yang, Y. T. C. (2019). Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course. *Thinking Skills and Creativity*, *31*, 1-10.

Lutsenko, G. (2018). Case study of a problem-based learning course of project management for senior engineering students. *European Journal of Engineering Education*, *43*(6), 895-910.

Martí, E., Gil, D., & Julià, C. (2006, March). A PBL experience in the teaching of computer graphics. In *Computer Graphics Forum* (Vol. 25, No. 1, pp. 95-103). 9600 Garsington Road, Oxford, OX4 2DQ, UK.: Blackwell Publishing Ltd..

McQuade, R. M., Ventura-Medina, E., Wiggins, S., & Anderson, T. (2018, September). The role of

institutional power in tutorless problem-based learning: students' interactional strategies for self-managing conflict in teamwork. In *46th SEFI Annual Conference*.

Mohd-Yusof, K., Alwi, S. W., Sadikin, A. N., & Abdul-Aziz, A. (2015). Inculcating sustainability among first-year engineering students using cooperative problem-based learning. In *Sustainability in higher education* (pp. 67-95). Chandos Publishing.

Nuutila, E., Törmä, S., & Malmi, L. (2005). PBL and computer programming—the seven steps method with adaptations. *Computer science education*, *15*(2), 123-142.

Patton, M. Q. (1990). *Qualitative evaluation and research methods*. SAGE Publications, inc.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, *9*(2), 5-15.

Schmidt, H. G. (1983). Problem-based learning: Rationale and description. *Medical education*, *17*(1), 11-16.

Scott, K. S. (2014). A multilevel analysis of problem-based learning design characteristics. *Interdisciplinary Journal of Problem-Based Learning*, *8*(2), 42-59.

Sedaghat, A. (2018). Factors affecting the team formation and work in project based learning (PBL) for multidisciplinary engineering subjects. *Journal of Problem Based Learning in Higher Education*, *6*(2).

Shelly, G. B., & Rosenblatt, H. J. (2012). Systems Analysis and Design Nineth Edition. *United States of America: Course Technology*.

Sulaiman, M. S., Jamaludin, M. H. I., & Derasit, Z. (2023). Code cody: A game-based learning platform for programming education. *Journal of ICT in Education*, *10*(1), 79-91.

Surendran, K., Ehie, I. C., & Somarajan, C. (2005). Enhancing student learning across disciplines: A case example using a systems analysis and design course for MIS and ACS majors. *Journal of Information Technology Education: Research*, *4*(1), 257-274.

Tan, O. S. (2021). *Problem-based learning innovation: Using problems to power learning in the 21st century*. Gale Cengage Learning.

Williams, M., & Ringbauer, S. E. (2014, June). PBL field deployment: Lessons learned adding a problem-based learning unit to a traditional engineering lecture and lab course. In *2014 ASEE Annual Conference & Exposition* (pp. 24-974).

Yew, E. H., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health professions education*, *2*(2), 75-79.

Yusof, K. M., Tasir, Z., Harun, J., & Helmi, S. A. (2005). Promoting problem-based learning (PBL) in engineering courses at the Universiti Teknologi Malaysia. *Global J. of Engng. Educ*, *9*(2), 175-184.

Zamroni, E., Lasan, B. B., & Hidayah, N. (2020, May). Blended learning based on problem based learning to improve critical thinking ability of prospective counselors. In *Journal of Physics: Conference Series* (Vol. 1539, No. 1, p. 012039). IOP Publishing.