Journal of Engineering Science and Technology
Special Issue on ISCoE2024 Vol. 20 No. 4 (2025) 150 - 157

PROBLEM-BASED WORKSHEET (PB-WS) ASSISTED LEARNING MANAGEMENT SYSTEM (LMS) FOR PNEUMATIC COURSE

NISAUDZAKIAH UTAMI[1], AGUS SETIAWAN[1,*], IDA HAMIDAH[1], JOHAR MAKNUN[1], THOMAS KÖHLER[2]

[1]Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Technische Universitat Dresden, Dresden, Germany
*Corresponding Author: agus_setiawan@upi.edu

Abstract

This research developed a problem-based worksheet (PB-Ws) model integrated with a learning management system (LMS) for the pneumatic course, targeting improvements in students' critical thinking and problem-solving skills. The study employed a four-phase design-based research (DBR) method: needs analysis, design planning, development, and reflection. The PB-Ws was validated by three expert validators. Data collection methods included interviews, observations, literature studies, and documentation. Results demonstrated that the PB-Ws model achieved a high feasibility level, particularly in the context (curriculum alignment and goal relevance), design, and language aspects, each scoring 4.0. However, input (adaptability to student characteristics) and process (implementation clarity and evaluation suitability) scored 3.7 and 3.3, suggesting areas for improvement in evaluation mechanisms and promotion of higher-order thinking skills (HOTS). This is because, although the model aligns with educational needs and standards, enhancements in cognitive challenge are necessary to maximize its effectiveness. The development of the PB-Ws model, integrated with LMS, significantly impacts vocational education by providing a structured, interactive, and accessible learning experience, supporting the cultivation of 21st-century skills in mechatronics and pneumatic systems.

Keywords: Higher order thinking skills, Learning management system, Problem-based learning, Vocational school, Worksheet.

1. Introduction

Problem-based worksheet (PB-Ws) is recognized as an innovative learning method that places students at the center of the learning process [1]. In pneumatic learning, students typically engage with worksheets as instructional materials. However, the worksheet developed in this study is not limited to conventional questions but is specifically designed to follow the problem-based learning (PBL) syntax. By presenting real-world problems at the beginning of the lesson, this worksheet guides learners systematically through the problem-solving process. Learning management systems (LMS) have emerged as effective platforms to support digital and flexible learning environments [2-4]. Integrating PB-Ws with LMS enables students to access materials, interact, and complete problem-based tasks independently and collaboratively [5].

Many reports regarding PBL have been well-documented [6-9]. Previous studies have demonstrated that the PBL approach enhances students' critical thinking and problem-solving abilities [10, 11]. However, these studies often relied on non-digital worksheets and lacked iterative model development tailored to students' needs.

This study aims to develop a PB-Ws model using LMS for the topic of pneumatic logic gates. Employing the design-based research (DBR) method, this research focuses on product development. The novelty of this study lies in three aspects: (i) the application of the Problem-Based Learning approach, (ii) the development of digital PB-Ws media, and (iii) the integration of LMS in pneumatic learning. This combination remains underexplored in engineering education, particularly in vocational contexts, and is expected to contribute to more interactive, flexible, and contextual learning.

2. Literature Review

Figure 1 shows the differences between a conventional worksheet and a problem-based worksheet (PB-Ws), comparing aspects such as: i) learning approach, ii) student engagement, iii) collaboration, iv) skill development, v)instructional design, and vi) effectiveness. New teaching strategies, like PBWs, must be implemented because conventional ones are often unsuccessful.

Figure 2 describes a general LMS diagram, which serves as a digital platform for managing, distributing, and monitoring the learning process [12]. Access to the LMS begins with the internet, where an administrator manages the web server and database server. Students input responses, while teachers upload instructional materials. The LMS supports both online and blended learning environments, providing features like material distribution, discussion forums, quizzes, assessments, and student activity tracking [13, 14]. In engineering education, LMS plays a critical role in delivering structured, self-directed learning experiences. Research found that applying LMS in electropneumatics training enables students to learn basic pneumatic principles online before engaging in hands-on practice, enhancing their readiness and technical skills [15]. LMS integration also allows for individualized monitoring of student progress, flexible learning schedules, and enhanced interaction through online discussions [16, 17]. Furthermore, combining LMS with active learning methods such as PBL has been shown to improve student independence and motivation [18].

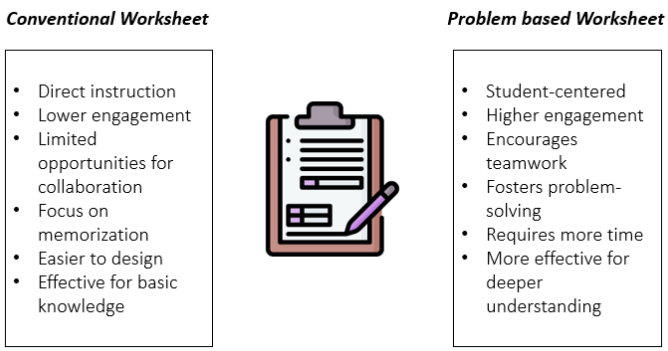

Fig. 1. Difference of a conventional worksheet and versus problem-based worksheet.

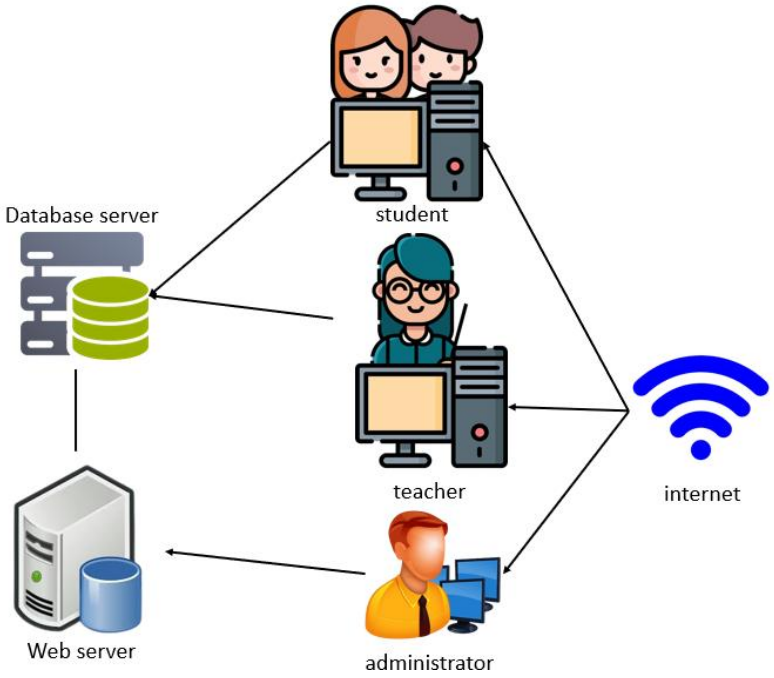

Fig. 2. Diagram of learning management system (LMS).

3. Method

This study applied the DBR method, consisting of four phases: analysis, design, development, and reflection. Detailed information for this method is explained elsewhere [19]. In the analysis phase, the study identified teachers' needs related to pneumatic learning. The PB-Ws design was developed to integrate the topic of pneumatic logic gates. During the development phase, three validators were involved: material experts, media experts, and design experts. The research instrument used was a PB-Ws validation sheet. The evaluation of PB-Ws effectiveness was conducted during the reflection phase.

4. Results and Discussion

Figure 3 explains the development of the PB-Ws model using the LMS platform. The needs analysis revealed that the worksheet design should support students in enhancing 21st-century skills and independently understanding fundamental material concepts [20]. Additionally, student activities must promote active, varied, and dynamic learning tailored to student characteristics [21]. Challenges in worksheet design often relate to the learning model applied, necessitating practical and accessible formats, both online and offline [22, 23]. The PB-Ws model follows five core stages: preparing the Moodle environment, conducting user testing, and performing monitoring and evaluation.

Figure 4 explains the PB-Ws interface within the LMS: Fig. 4(a) for login page with fields for Username and Password and options for language settings and password recovery; Fig. 4(b) for course dashboard; Fig. 4(c) for introduction page; Fig. 4(d) for subject identity section detailing competencies, objectives, and descriptions; Fig. 4(e) for module-based teaching materials; Fig. 4(f) for pretest and posttest features; and Fig. 4(g) for structured learning sessions. Activities include problem presentation, group formation, investigation, solution presentation, and reflection, fostering critical thinking, collaboration, and problem-solving skills.

Table 1 explains validation results from three expert validators who indicated that the PB-Ws model achieved a high feasibility level. Detailed information for statistical analysis is explained elsewhere [24-26]. The context aspect (curriculum alignment, learning objectives, and student needs) scored 4.0. The input aspect (adaptability to student characteristics) and the process aspect (clarity of implementation and evaluation) scored 3.7 and 3.3, respectively, signaling areas for improvement, particularly in evaluation mechanisms and promoting higher-order thinking skills (HOTS). Suggestions included adjusting learning activities to model syntax, refining implementation stages, and correcting writing errors. Limited-scale implementation of PB-Ws using LMS showed significant improvements in students' critical thinking and problem-solving skills based on pretest and posttest N-Gain calculations. These results confirm the model's strong alignment with curriculum standards and student needs, though improvements in evaluation and cognitive challenge remain necessary for optimal effectiveness [27].

Table 1. Validation result.

Aspect	Number of Items	Score
Learning objectives and curriculum Structure	1,2	4.0
Fit the purpose to the needs	3,4,5,6,7	4.0
Fit of the model with the characteristics and needs of the students	8,9,10,11,12,13,14,15,16,17	3.7
Clarity of the stages of implementation of the learning model	18,19,20,21	3.7
Conformity of learning evaluation	22,23,24,25,26	3.3
Model compatibility with HOTS	27,28	3.3
Design and Appearance	29,30,31,32	4.0
Language	33,34,35,36,37	4.0

The PB-Ws model, integrating PBL syntax within an LMS, emphasizes indicators of critical thinking and problem-solving. Its design has proven valid and reliable, ensuring suitability for vocational learning environments [28-34]. Systematic arrangement and continuous refinement, the PB-Ws supports teachers in facilitating engaging and effective learning while promoting students' 21st-century skills.

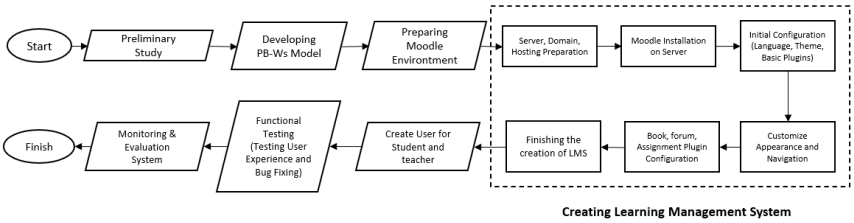

Fig. 3. Flowchart design PB-Ws using LMS.

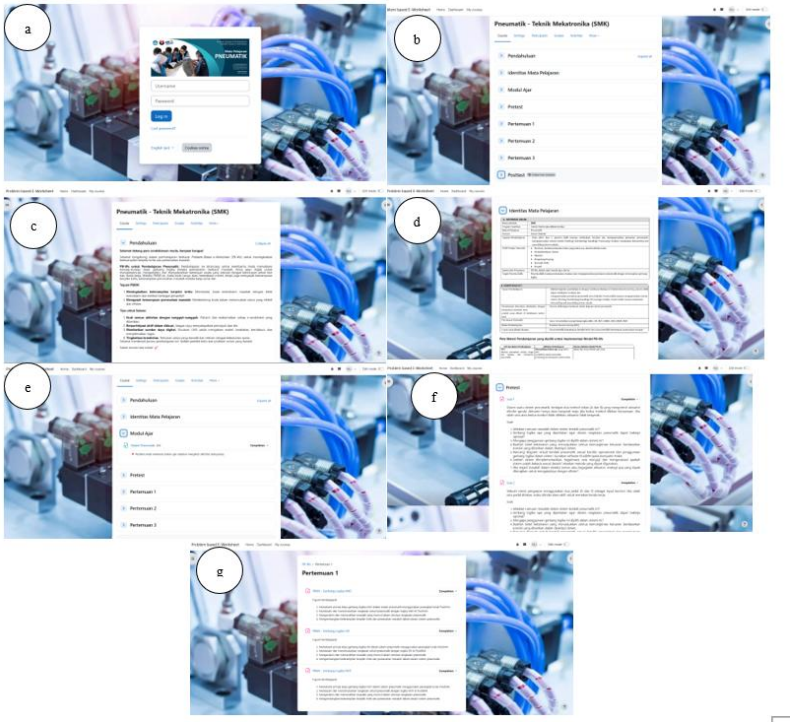

Fig. 4. PB-Ws using LMS: a) Login page, b) course dashboard, c) introduction page, d) subject identity, e) module-based teaching materials, f) pretest and posttest, g) structured learning sessions.

5. Conclusion

The PB-Ws model is deemed feasible for use in the learning process. It demonstrates strong alignment with the curriculum structure and student needs, achieving maximum scores in the context, design, and language aspects. However,

certain areas, particularly in learning scenario preparation and activity structuring, require improvement, as reflected in the lower scores for the process and product aspects. Overall, the PB-Ws model shows significant potential to enhance the effectiveness of problem-based learning. With further refinement, it can serve as an optimal tool to support the development of HOTS among students.

Acknowledgement

This study was supported by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia through Grant PKPI PMDSU (2127/E4/DT.04.02/2024).

References

1. Wang, C.C. (2021). The process of implementing problem-based learning in a teacher education programme: An exploratory case study. *Cogent Education*, 8(1), 1-13.
2. Ara, S.J.S.; Tanuja, R.; Manjula, S.H.; and Venugopal, K.R. (2023). A comprehensive survey on usage of learning analytics for enhancing learner's performance in learning portals. *Journal of Educational Technology Systems*, 52(2), 245-273.
3. Soko, Y.; Mpundu, M.; and Yangailo, T. (2024). Determinants of learning management system (LMS) adoption by university students for distance learning. *Indonesian Journal of Educational Research and Technology*, 4(2), 171-186.
4. Al Husaeni, D.N.; and Hadianto, D. (2022). The influence of spada learning management system (LMS) on algorithm learning and programming of first grade students at Universitas Pendidikan Indonesia. *Indonesian Journal of Multidiciplinary Research*, 2(1), 203-212.
5. Hidayah, K.F.; Hairun, S.Y.; and Sari, D.P. (2020). Design of PBL-based differential calculus module to stimulate students' critical thinking skills. *Universal Journal of Educational Research*, 8(7), 2778-2793.
6. Arifiani, I.; Nurul, H.L.; and Rahmawan, S. (2025). Problem-based learning (PBL) learning model for increasing learning motivation in chemistry subject: Literature review with bibliometric analysis. *ASEAN Journal for Science Education*, 4(1), 17-30.
7. Rahmadani, W.; Winarno, N.; Sriyati, S.; and Supriyatin, T. (2024). Problem-based learning on students' attitude towards science: An action research. *ASEAN Journal of Science and Engineering Education*, 4(2), 133-142.
8. Awofala, A.O.A.; and Akinoso, S.O. (2024). Altering students' mindsets and enhancing engagement in mathematics in a problem-based learning. *ASEAN Journal of Science and Engineering Education*, 4(2), 193-210.
9. Saidirasilovna, U.N. (2025). Preparing future geography teachers through problem-based learning technology: A short review. *ASEAN Journal for Science Education*, 4(1), 39-44.
10. Faizal, S.; and Nadhirah, F. (2025). Students' perspectives on the effectiveness of project-based learning in higher education. *Journal of Education and Applied Teaching* (*JEAT*), 1(1), 41-49.

11. Iryna, R.; Serhii, P.; Nataliia, H.; Kushevska, N.; and Tetiana, S. (2022). Innovative technology of teaching Moodle in higher pedagogical education: From theory to pactice. *International Journal of Computer Science & Network Security*, 22(8), 153-162.
12. Elfeky, A.I.M.; and Elbyaly, M.Y.H. (2023). The use of data analytics technique in learning management system to develop fashion design skills and technology acceptance. *Interactive Learning Environments*, 31(6), 3810-3827.
13. Williams, K.M.; and Donlan, A.E. (2023). Online assessment in large undergraduate courses during Covid-19 emergency response teaching. *Journal of Educational Research and Practice*, 13(1), 476-496.
14. Ononiwu, C. (2021). Role of online discussion forums in enhancing users'cognitive skills. *Journal of Teaching English for Specific and Academic Purposes*, 9(3), 307-320.
15. Jain, S.; Prabha, C.; Nandan, D.; and Bhosale, S. (2024). Comparative analysis of frequently used e-learning platforms. *Frontiers in Education*, 9, 1-7.
16. Qazdar, A.; Hasidi, O.; Qassimi, S.; and Abdelwahed, E.H. (2023). Newly proposed student performance indicators based on learning analytics for continuous monitoring in learning management systems. *International Journal of Online and Biomedical Engineering*, 19(11), 19-30.
17. Shanmuganeethi, V.; Muthuramalingam, S.; and Uma, K.V. (2020). Intelligent dynamic grouping for collaborative activities in learning management system. *Journal of Engineering Education Transformations*, 34(2), 108-116.
18. Silva, A.B.; Bispo, A.C.; Rodriguez, D.G.; and Vasquez, F.I. (2018). Problem-based learning: A proposal for structuring PBL and its implications for learning among students in an undergraduate management degree program. *Revista de Gestão*, 25(2), 160-177.
19. Susilawati, A.; Al-Obaidi, A.S.M.; Abduh, A.; Irwansyah, F.S.; and Nandiyanto, A.B.D. (2025). How to do research methodology: From literature review, bibliometric, step-by-step research stages, to practical examples in science and engineering education. *Indonesian Journal of Science and Technology*, 10(1), 1-40.
20. Yusuf, I.; and Widyaningsih, S.W. (2022). Higher order thinking skills oriented student worksheet of e-learning model in electric circuit topic. *TEM Journal*, 11(2), 564-573.
21. Garwood, J. (2020). Escape to learn! An innovative approach to engage students in learning. *Journal of Nursing Education*, 59(5), 278-282.
22. Issufiah, N.; Sunardi, S.; Sri, W.; and Gunarhadi, G. (2018). The implementation off problem-based learning model (PBL) on teachers and students grade five elementary schools in Surakarta city. *International Journal of Active Learning*, 3(2), 116-123.
23. Burkholder, E.; Mohamed-Hinds, N.; and Wieman, C. (2021). Evidence-based principles for worksheet design. *The Physics Teacher*, 59(6), 402-403.
24. Fiandini, M.; Nandiyanto, A.B.D.; Al Husaeni, D.F.; Al Husaeni, D.N.; and Mushiban, M. (2024). How to calculate statistics for significant difference test using SPSS: Understanding students comprehension on the concept of steam

engines as power plant. *Indonesian Journal of Science and Technology*, 9(1), 45-108.

25. Rahayu, N.I.; Muktiarni, M.; and Hidayat, Y. (2024). An application of statistical testing: A guide to basic parametric statistics in educational research using SPSS. *ASEAN Journal of Science and Engineering*, 4(3), 569-582.
26. Afifah, S.; Mudzakir, A.; and Nandiyanto, A.B.D. (2022). How to calculate paired sample t-test using SPSS software: From step-by-step processing for users to the practical examples in the analysis of the effect of application anti-fire bamboo teaching materials on student learning outcomes. *Indonesian Journal of Teaching in Science*, 2(1), 81-92.
27. Hailikari, T.; Virtanen, V.; Vesalainen, M.; and Postareff, L. (2022). Student perspectives on how different elements of constructive alignment support active learning. *Active Learning in Higher Education*, 23(3), 217-231.
28. Hajjar, S.T. (2018). Statistical analysis: Internal-consistency reliability and construct validity. *International Journal of Quantitative and Qualitative Research Methods*, 6(1), 27-38.
29. Ambarita, C.F.; Ambarita, D.P.; Simanullang, R.S.P.; Sirait, D.E.P.; and Hutahaean, H.D. (2022). The development of e-book learning media based PBL. *International Journal of Computer Applications Technology and Research*, 11(1), 7-11.
30. Choirunnisa, A.; and Trisnawati, N. (2024). Development of problem-based learning e-LKPD for digital-based documents. *SAR Journal*, 7(3), 178-183.
31. Situmorang, M.; Yustina, Y.; and Syafii, W. (2020). E-module development using Kvisoft flipbook maker through the problem-based learning model to increase learning motivation. *Journal of Educational Sciences*, 4(4), 834-848.
32. Muqtashidah, F. (2025). Developing web-based e-LKPD with PjBL model to enhance psychomotor skills in scripting. *Journal of Education Technology and Information System*, 1(02), 3390-3394.
33. Sukrisnawan, I.K.; Margunayasa, I.G.; and Trisna, G.A.P.S. (2023). Appsmart learning application based on PBL model assisted by articulate storyline 3 on electrical energy material. *Jurnal Edutech Undiksha*, 11(2), 277-287.
34. Putri, R.A.; Uchtiawati, S.; Fauziyah, N.; and Huda, S. (2020). Development of interactive learning media flip-book using Kvisoft flipbook maker based on local culture arts. *Innovation Research Journal*, 1(1), 55-64.