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Research Article

Development of Problem-Based Learning E-LKPD to Improve Mathematical Problem-Solving Ability and Self-Confidence of High School Students on Quadratic Equations

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Abstract: This study aims to: (1) produce e-LKPD based on problem-based learning oriented to mathematical problem-solving ability and self-confidence of high school students on the material of equations and quadratic functions and (2) describe the feasibility of PBL-based e-LKPD oriented to mathematical problem- solving ability and self-confidence of high school students on the material of equations and quadratic functions seen from the aspects of validity, practicality, and effectiveness. This type of research is research and development using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The research was conducted at SMA Negeri 1 Malinau with the research subject of class X-3 students totaling 35 students. Data collection was carried out using interview techniques, observation, e-LKPD validation sheets, pretest-posttest, and questionnaires. To determine the validity, the e-LKPD assessment sheet of material and media experts was used, practicality used student and teacher response questionnaires, and effectiveness used mathematics problem solving ability test questions and student self-confidence questionnaires. Data analysis consisted of qualitative data analysis and quantitative data analysis. Qualitative data analysis was conducted by analyzing the results of interviews, observations, and comments or suggestions given to make improvements to the e-LKPD products developed. Quantitative data analysis was conducted by converting quantitative data into qualitative data in the form of certain categories, normality test using shapiro-wilk, t-test with paired samples test, and N-Gain score. The results showed: (1) PBL-based e-LKPDs oriented towards mathematical problem solving skills and self-confidence of high school students on the material of quadratic equations and functions have been produced, (2) PBL-based e-LKPDs developed meet product feasibility, namely valid with excellent categories based on material and media experts; practical with very practical categories based on teacher responses and practical based on student responses; effective on math problem solving skills with classical completeness of 77%, the t-test results obtained a significance value of 0.000 <0.05 which means that there is a difference in the average ability to solve mathematical problems before and after learning using e-LKPD, the N-Gain result is 0.65 with moderate criteria, and effective on student self-confidence with an increase in the average score of each indicator before and after learning, the N-Gain result is 0.49 with moderate criteria, and the t-test results with a significance value of 0.000 < 0.05.

Keywords: E-LKPD; Math Problem-Solving Ability; Problem-Based Learning; Self-Confidence

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1. Introduction

In facing the challenges of the 21st century, education is required to equip students with critical thinking skills, creativity, collaboration, and technological literacy. Mathematics, as a fundamental subject, has a big role in shaping logical thinking and solving real-life problems (Ministry of Education and Culture, 2020; Maulyda, 2020). Problem-solving skills are one of the main competencies in mathematics learning, as stated in the Decree of the Head of BSKAP No. 008/H/KR/2022 and NCTM standards (2000). However, in reality, students'

interest and mathematics learning outcomes are still relatively low. This is evident from the results of PISA 2022 which show that the majority of Indonesian students have not achieved basic competencies in mathematics, as well as the results of observations and interviews at SMAN 1 Malinau which show the weak mathematical problem-solving skills of students (OECD, 2023).

One of the factors that affect the low learning outcomes of mathematics is the lack of student confidence. Students who are not confident tend to be reluctant to take risks in learning, including to ask questions and explain their answers in front of the class (Nufus & Duskri, 2018). Previous research has shown that self-confidence has a significant influence on students' engagement in learning and their ability to complete academic tasks (Moneva & Tribunalo, 2020). Therefore, efforts are needed that are able to develop two aspects at once, namely mathematical problem-solving skills and student confidence.

The problem-based learning (PBL) learning model is seen as the right approach to achieve this goal because it requires students to think critically in dealing with real problems, as well as train their courage in expressing opinions and solutions (Havenga et al., 2023). In addition, learning media such as LKPD, especially in electronic form (e-LKPD), are important to support PBL to be more attractive, flexible, and in accordance with the characteristics of current students (Prastowo, 2015; Kosasih, 2021). Several previous studies have proven that PBL-based e-LKPD can improve students' critical thinking skills, mathematical communication, and self-confidence (Purnama & Suparman, 2020; Husna et al., 2022; Kurniawan et al., 2019).

However, at SMAN 1 Malinau, the use of LKPD and e-LKPD is still very limited. The condition was further aggravated by the massive flood that damaged learning facilities such as textbooks. In fact, this school has great potential to take advantage of digital learning, as students are used to using devices and the internet network in schools is relatively stable. The material on equations and quadratic functions, which is the focus of the Independent Curriculum for class X, is considered important but remains a big challenge for students due to its complexity (Azmi & Yunita, 2022; Komalasari, 2020).

Based on these problems, this study aims to develop a PBL-based e-LKPD designed not only to improve the ability to solve mathematical problems, but also the self-confidence of high school students. This study is different from the previous study because it integrates the two variables in one learning product and focuses on the material on equations and quadratic functions at the high school level.

2. Literature Review

Mathematics learning is an interactive process between teachers and students that aims to develop thinking skills and mathematical problem-solving. Mathematics, as a universal science, plays an important role in the advancement of modern technology and is applied to various fields (Keller et al. in Maulyda, 2020). Effective learning integrates abstract concepts with real-world situations (Vandini in Andayani & Amir, 2019) and involves teaching strategies that motivate students, facilitate interaction, and measure goal achievement (NCTM, 2000; Bell, 1978). In the context of the Independent Curriculum, the objectives of mathematics learning include understanding concepts, reasoning, communication, connection, representation, as well as positive and confident attitudes (BSKAP, 2022). The focus of this research is the ability to solve mathematical problems that require in-depth analysis to solve non-routine problems (Hendriana & Soemarmo in Damayanti & Kartini, 2022) as well as strengthening students' self-confidence.

The research material focuses on quadratic equations and functions, including solving methods such as factoring, completing squares, quadratic formulas, and function graphs (Noormandiri, 2021). The quadratic function has the characteristics of a parabolic graph with various applications in everyday problem solving (Blitzer, 2018; Lippman & Rasmussen, 2017). Mastery of this material is an important basis for advanced and applicable mathematics learning in other fields (Azmi & Yunita, 2022).

The Student Worksheet (LKPD) is a teaching material containing guides, materials, and exercises to support the student learning process systematically (Choo et al., 2011; Prastowo, 2015). LKPD functions to facilitate student involvement, develop concepts, and make it easier for teachers to manage learning (Kosasih, 2021). To support learning innovation, LKPD can be developed in digital form or e-LKPD that allows for the integration of graphics, animation, audio, and interactivity (Sulistiani et al., 2022). Previous research has shown that

problem-based learning (PBL)-based e-LKPD is effective in improving students' problem-solving skills and self-confidence (Husna et al., 2022).

The PBL model positions students as the center of learning by exposing them to contextual problems that drive information search and the formulation of solutions (Corrêa & Martins in Havenga et al., 2023). PBL has been proven to improve students' critical thinking, problem-solving, and self-confidence skills (Setyo et al., 2020; Hendriana et al., 2018). In this study, e-LKPD is designed based on PBL using Wizer.Me applications to integrate equation and quadratic function materials with indicators of students' problem-solving ability and self-confidence, so that learning is more interesting, interactive, and in accordance with the needs of the 21st century.

3. Proposed Method

This research adopts the ADDIE development model which includes five main stages, namely Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it is systematic and in accordance with the needs in developing learning media such as e-LKPD based on Problem Based Learning (PBL). The first stage begins with a needs analysis which is carried out through observation and interviews with teachers and students to identify learning problems and needs. Furthermore, the design stage involves the initial design of the e-LKPD based on the results of the analysis, including the structure of the content, display, and preparation of research instruments. At the development stage, researchers began to create e-LKPD according to the design that had been prepared and involved validation by material experts, media, and education practitioners (Akbar, 2013).

The product development procedure was continued with a small group trial and a field trial. The subject of the limited trial consisted of six students in class XI of MIPA, while the broad trial involved 30 students at the same level. Data collection techniques are carried out through observation, interviews, validation questionnaires, and learning outcome tests. The instruments used include expert validation sheets, practicality sheets, and cognitive tests to measure student learning outcomes. Validation is carried out by three experts: material experts, media experts, and teachers as practitioners, to ensure the quality of the content and technical of the e-LKPD. The data obtained were analyzed by quantitative and qualitative descriptive analysis techniques. The assessment of product validity is calculated using the percentage of feasibility, while practicality and effectiveness are analyzed from the scores of practicality and student learning outcomes, both individually and classically (Nieveen, 1999).

4. Results and Discussion

Initial Product Development Results

The development of e-LKPD based on *Problem-Based Learning* (PBL) on equations and quadratic functions for high school students in class X was carried out using the ADDIE model, which includes five stages, namely *analysis*, *design*, *development*, *implementation*, and *evaluation*. In the *analysis stage*, the researcher conducts a needs analysis through observation and interviews with teachers and questionnaires to students. The results showed that most teachers still use printed LKPD and 64% of students have never used e-LKPD, but 89% expressed interest in using it in mathematics learning. Student analysis includes identification of characteristics, initial problem-solving skills, and *self-confidence*. Curriculum analysis was carried out to adjust the e-LKPD to learning outcomes and school policies.

The *design stage* focuses on designing the e-LKPD structure which refers to the PBL syntax, including the preparation of teaching modules, learning activity designs, assessment instruments, and *draft* e-LKPD using Wizer.me and Canva applications. The assessment instrument is validated to ensure the feasibility of content, language, and graphics.

The *development stage* includes the creation of e-LKPD according to design, validation by material and media experts, and revision based on input. Readability tests were carried out on 9 students to see language and graphic aspects, then the product was revised.

The *implementation* phase involves a trial in class X-3 of SMA Negeri 1 Malinau, equipped with a pre-test and post-test of problem-solving skills, *a self-confidence questionnaire*, and a questionnaire of student and teacher responses to assess practicality.

The *evaluation stage* is carried out to measure the practicality and effectiveness of the product. The questionnaire data showed that e-LKPD was practically used, while the test

results showed a significant improvement in students' problem-solving ability (N-Gain 0.65) and *self-confidence* (N-Gain 0.49) in the medium category. The final revision is made based on teacher and student feedback to improve the product so that it is suitable for use in mathematics learning in high school.

Product Revision

The revision of the e-LKPD product based on Problem-Based Learning (PBL) was carried out through three stages based on input from expert validators, students, and mathematics teachers. Revision I was carried out after validation by material and media experts, including simplifying the font types into two types, uniformizing the design in all sections, adjusting the price of the wire to make it more realistic, arranging the table of contents with page numbers on the right side, adding technical instructions to each activity such as "Let's Understand" and "Let's Plan", as well as replacing the learning video so that it is free of advertising and adding new videos to the quadratic function material. Revision II was carried out after a readability test by nine students in class X-2, who found the cover attractive and the content easy to understand, but suggested the addition of contextual images and color variations to make them more attractive. Revision III was carried out based on the input of the mathematics teacher of SMA Negeri 1 Malinau and the students' response to the field trial. Improvements are focused on clarity of terms in the learning video, for example changing the phrase "the last number" to "constant number" with an explanation of the coefficient of the xxx variable, as well as improving the scoring of the "Let's Interpret" activity from 3 to 2. The final results of the revision show that the e-LKPD is suitable for use and recommended for development and dissemination to other teachers.

Final Product Review

The final product of the e-LKPD based on Problem-Based Learning (PBL) developed has characteristics including: compiled using the Canva and Wizer.me applications, consisting of two learning subtopics, namely quadratic equations and quadratic functions, and contains PBL steps that are integrated with indicators of students' mathematical problem-solving ability and self-confidence. This product can be accessed through an internet-connected smartphone or laptop, with an interactive and attractive display according to today's digital learning demands (JK & Yuliani, 2021; April & Mulyatna, 2021).

From the aspect of validity, the results of the assessment of two expert lecturers showed that the category was very good, both in material experts (score 64 out of a maximum of 80) and media experts (score 80.5), which is in line with the opinion of Djamas et al. (2018) that product quality is considered valid if it meets the good category at least. In terms of practicality, the response of five teachers of SMA Negeri 1 Malinau gave an average score of 3.71 (very practical category), while 35 students gave an average score of 3.20 (practical category).

This meets the criteria of Van den Akker (1999) and Manden in Lase & Zai (2022) that a product is practical if it gets a positive assessment from the user. In terms of effectiveness, the results of the field trial showed that the classical completeness of mathematical problem-solving ability reached 77% (above the minimum limit of 75%), there was a significant difference between pre-test and post-test ($p < 0.05$), and an N-Gain value of 0.65 (medium category). The increase in student self-confidence was also significant with an N-Gain of 0.49 (medium category). This achievement is in line with the view of Van den Akker (1999) and the findings of Rahayu et al. (2019) and Ismail & Imawan (2022) that PBL is effective in improving mathematical problem-solving skills. Thus, the e-LKPD developed meets the valid, practical, and effective criteria to support mathematics learning on equation and quadratic function materials.

5. Conclusions

Based on the results of the research, an e-LKPD based on Problem-Based Learning (PBL) was developed which is oriented towards improving the mathematical problem-solving skills and self-confidence of high school students in equation and quadratic function materials. Product development follows the stages of the ADDIE model, including analysis of needs, student characteristics, and curriculum; design of e-LKPD, learning instruments, and validation sheets; product development and validation by material and media experts, revision, and readability testing; implementation in the form of trials in class X-3, pre-test-

posttest, as well as self-confidence questionnaires and student-teacher responses; and evaluation to assess the practicality and effectiveness of the product. The test results showed that the e-LKPD met the eligibility criteria: valid with an excellent category of material and media experts; practical based on teacher and student responses; and effectively improve mathematical problem-solving skills and self-confidence. Effectiveness was demonstrated by 77% classical completeness, significant differences in pretest–posttest scores (sig. 0.000 < 0.05), and N-Gain 0.65 (moderate) in problem-solving ability; as well as an increase in the score of each self-confidence indicator, N-Gain 0.49 (moderate), and t-test results showing a significant difference (sig. 0.000 < 0.05) between before and after the use of e-LKPD.

References

Akbari, O., & Sahibzada, J. (2020). Students' self-confidence and its impacts on their learning process. American International Journal of Social Science Research, 5(1), 1-15. https://doi.org/10.46281/aijssr.v5i1.462

Andayani, M., & Amir, Z. (2019). Membangun self-confidence siswa melalui pembelajaran matematika. Desimal: Jurnal Matematika, 2(2), 147-153. http://dx.doi.org/10.24042/djm.v2i2.4279

Apriliyani, S. W., & Mulyatna, F. (2021). Flipbook e-LKPD dengan pendekatan etnomatematika pada materi teorema Phytagoras. Prosiding Seminar Nasional Sains (Sinasis), 491-500.

Azmi, N., & Yunita, R. (2022). Analisis kesulitan siswa dalam menyelesaikan masalah fungsi kuadrat di kelas X MAN 6 Aceh Utara. Ar-Riyadhiyyat: Jurnal Pendidikan Matematika, 3(1), 41-49. https://doi.org/10.47766/arriyadhiyyat.v3i1.513 https://doi.org/10.47766/arriyadhiyyat.v3i1.513

Bell, F. H. (1978). Teaching and learning mathematics in secondary schools. Wm. C. Brown Company.

Blitzer, R. (2018). College algebra (7th ed.). Pearson Education.

Choo, S. S. Y., Rotgans, J. I., Yew, E. H. J., & Schmidt, H. G. (2011). Effect of worksheet scaffolds on student learning in problem-based learning. Advances in Health Sciences Education, 16(4), 517-528. https://doi.org/10.1007/s10459-011-9288-1 PMid:21409538

Damayanti, N., & Kartini. (2022). Analisis kemampuan pemecahan masalah matematis siswa SMA pada materi barisan dan deret geometri. Mosharafa: Jurnal Pendidikan Matematika, 11(1), 107-118. http://journal.institutpendidikan.ac.id/index.php/mosharafa https://doi.org/10.31980/mosharafa.v11i1.1162

Djamas, D., Tinedi, V., & Yohandri. (2018). Development of interactive multimedia learning materials for improving critical thinking skills. International Journal of Information and Communication Technology Education (IJCTE), 14(4), 66-84. https://doi.org/10.4018/IJICTE.2018100105

Havenga, M., Olivier, J., & Bunt, B. J. (Eds.). (2023). Problem-based learning and pedagogies of play: Active approaches towards self-directed learning (Vol. 11). AOSIS Books. https://doi.org/10.4102/aosis.2023.BK409

Hendriana, H., Johanto, T., & Sumarmo, U. (2018). The role of problem-based learning to improve students' mathematical problem-solving ability and self-confidence. Journal on Mathematics Education, 9(2), 291-300. http://dx.doi.org/10.22342/jme.9.2.5394.291-300

Husna, N. H., Marzal, J., & Yantoro, Y. (2022). Pengembangan e-LKPD berbasis problem based learning untuk meningkatkan kemampuan pemecahan masalah matematis siswa. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11(3), 2085-2095. https://doi.org/10.24127/ajpm.v11i3.4914

Ismail, R., & Imawan, R. (2022). The effectiveness of problem-based learning in terms of learning achievement, problem-solving, and self-confidence. Advances in Social Science, Education and Humanities Research: Proceedings of the 5th International Conference on Current Issues in Education, 238-243. https://doi.org/10.2991/assehr.k.220129.043

JK, A. K. R., & Yuliani. (2021). Pengembangan lembar kerja peserta didik elektronik (e-LKPD) berbasis inkuiri pada submateri fotosintesis untuk meningkatkan kemampuan argumentasi peserta didik. BioEdu, 10(3), 663-673. https://doi.org/10.26740/bioedu.v10n3.p663-673

Kementerian Pendidikan dan Kebudayaan. (2020). Desain pengembangan soal AKM. Pusat Asesmen dan Pembelajaran, Penelitian dan Pengembangan Perbukuan.