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Developing Edpuzzle-assisted e-Worksheet to Enhance Students' Critical Thinking Skills in Problem-based Learning

Furqon Firmansyah, Andriyani*
Universitas Ahmad Dahlan, Jl. Pramuka No.42, Pandeyan, Kec. Umbulharjo, Kota Yogyakarta, Daerah Istimewa Yogyakarta 55161, Indonesia
e-mail: andriyani@mpmat.uad.ac.id

Abstract

This study aims to produce an Edpuzzle-assisted mathematics e-worksheet that is feasible to improve the grade VII junior high school students' critical thinking skills in problem-based learning. This study also aims to test the effectiveness of the e-worksheet in improving the critical thinking skills. It was a development research using 4D model (define, design, develop and disseminate). The results of this research show that the Edpuzzle-assisted mathematics e-worksheet is feasible to be used to improve the critical thinking skills of junior high school students in grade VII based on the validation of material experts, media experts, and students' responses. Furthermore, the e-worksheet is effective to improve the critical thinking skills of junior high school students in grade VII based on the results of gain score test with the category of increasing pre-test and post-test by 84.04%.

Keywords: e-worksheet, problem-based learning, social arithmetic

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INTRODUCTION

Critical thinking is the capacity to ask and/or respond to deep questions in a way that enhances overall understanding (Hildson in Wale & Bishaw, 2020). This skill comprises translation, analysis, evaluation, synthesis, inference, and self-regulation. To improve students' problem-solving, decision-making, and communication skills, it is crucial to equip them with critical thinking knowledge at school, especially in mathematics education. This effort can be made by incorporating critical thinking into the teaching and learning process (Sharadgah, 2014). Various teaching strategies (such as problem-based learning) promote the development of these skills in students, as they can help them develop fundamental critical thinking competencies, such as interpretation, analysis, inference, explanation, and self-regulation (Aini et al., 2019; Nadeak & Naibaho, 2020; Seibert, 2021).

Critical thinking has emerged as a key skill for students to master in an era where people must make decisions more frequently than ever before (Niu, Behar-Horenstein, & Garvan, 2013). Although critical thinking is crucial in problem-solving practices, for example, in classroom learning, the case at SMP Muhammadiyah 25 Paciran still requires serious attention to learning outcomes. This need is indicated by their low critical thinking skills, as represented by an initial test. In the test, out of 30 students who took the test, only 3 passed. This situation is certainly unfortunate compared to the enormous benefits of critical thinking. This also emphasizes the students' weaknesses in understanding mathematics lessons in class so far. The students' weakness in critical thinking and their low achievement in mathematics is the basis for the urgency of this research. Besides, studying mathematics is indeed not easy, especially when the teaching model used is very traditional, such as lectures. This disparity, as shown by Acharya (2017), is that students' failure in mathematics is often due to a lack of connection between new mathematical concepts and the mathematical structure previously taught by the teacher, math anxiety, and negative feelings towards

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mathematics. One solution to the problems in mathematics learning is through Problem-Based Learning (PBL), which is a concept for acquiring information and literacy. Therefore, the PBL approach in learning can be an alternative or solution to this problem. Social arithmetic, as a subject that can apply mathematical concepts to social situations, involves the use of mathematical reasoning to analyze and interpret data related to social problems. Thus, studying social arithmetic can be very important for developing critical thinking skills among students as it requires them to apply these skills to real-world problems (Hobri, Oktavianingtyas, Trapsilasiwi, Murtikusuma, & A'yun, 2020).

Additionally, social arithmetic can help students develop a more nuanced understanding of social issues (Macías-Rivas, 2012). For example, by analyzing data on poverty levels in various communities, students can understand how poverty is related to factors such as race, gender, and education. This can help them develop a more informed and empathetic perspective on social issues. To escalate the use of previous knowledge, collaborative learning, and active engagement in learning, Problem-Based Learning (PBL) utilizes constructivist principles. A small group of students analyzes a problem, finds related information, and applies prior knowledge and experience in solving the problem (Zhou, 2018). Problems in PBL exercises should be common work-related or situational issues with unclear information, such as poorly structured case studies (Miner-Romanoff, Rae, & Zakrzewski, 2019). The use of less-structured case studies encourages students to explore their options and seek information independently; this is an important skill in nursing and can be a first step towards resilience.

In PBL, the teacher acts as a facilitator, not an instructor. By organizing information, guiding exploration, ensuring that difficult concepts can be understood, and providing resources, the facilitator helps the group connect concepts and build understanding (Seibert, 2021). Facilitators also encourage reflection on group dynamics and outcomes. They can also be seen as coaches or mentors who provide advice and support (Salari, Roozbehi, Zarifi, & Tarmizi, 2018). The group is guided by a facilitator who also encourages critical thinking. Researchers use the Edpuzzle-assisted learning paradigm as an instrumental aid to enhance critical thinking skills. A tool that teachers can use in teaching is Edpuzzle, a video-sharing platform. This allows teachers to ensure that students have watched the entire lesson and determine whether they understand its content (Mischel, 2019). The use of Edpuzzle in learning can be very helpful, especially the material format packaged in video form.

Lessons through videos are used in education in various ways. Previous research has found that students who use online videos to enhance their learning achieve higher cumulative test scores than those who learn traditionally (Caviglia-Harris, 2016). As online learning becomes more popular and dependent on videos, the need to use videos more effectively becomes important so that students can maximize their learning. One study supports learning by watching videos (Kay, 2012). Another study reported that students believe that using videos has a direct positive impact on their learning outcomes and abilities (van Alten, Phielix, Janssen, & Kester, 2020). Carmichael, Reid, & Karpicke (2018) reported that using videos actually improves students' critical thinking skills. Based on the previously outlined urgency, researchers intend to study and develop a Mathematics E-Worksheet Assisted by Edpuzzle with a Problem-Based Learning Model to Improve Students' Critical Thinking Skills.

RESEARCH METHOD

This research uses a 4D engineering approach (Define, Design, Develop, and Disseminate) to develop learning media for class VII students of SMP Muhammadiyah 25 Paciran who have

low achievement and critical thinking skills in mathematics subjects. The 4D model is used to create E-worksheet with the help of Edpuzzle which is based on PBL (Problem-Based Learning). The results of this development will be accessible via the web 2.0 system both via cell phone and desktop. The hope is that these instructional resources will improve students' critical thinking skills in mathematics learning. The process of developing PBL-based Edpuzzle-assisted Mathematics -LKPD using a 4D model.

The first stage is definition, which consists of Preliminary Analysis: A preliminary study is carried out through interviews and observations to identify mathematics learning problems in schools. Learner Analysis: Involves interviews with teachers and homeroom teachers to understand learner characteristics, including academic abilities and use of technology. Concept Analysis: Compile and identify mathematics learning concepts and critical thinking skills that will be taught, and evaluate their relevance to PBL. Test Analysis: Determine the tasks in the form of tests that are appropriate for the development of this E-worksheet, by modifying the questions to reflect critical thinking skills. Learning objective specifications are determined based on the results of the analysis to meet students' mathematics learning needs and critical thinking abilities.

The second stage is the Planning Stage (Design). At this stage, the form and content of the media that will be created will be designed in the form of a development guide, flowchart and initial appearance of the E-WORKSHEET. Making this E-WORKSHEET was done by exploring various tools in Edpuzzle and adapting it to research needs. Apart from that, making this E-WORKSHEET certainly requires basic material formulated by researchers. However, other access in the form of videos, video designs and other displays can be done automatically by Edpuzzle. At the design stage, critical thinking skills test questions were also created. These questions are prepared according to the material that appears in the LKPD content and are also prepared based on indications of the critical thinking skills being studied. There are pretest questions and posttest questions to measure the development of students' critical thinking skills during learning. n (design).

The third stage is development (Develop). At the development stage, product validation is carried out by involving experts to evaluate the suitability of the questions that have been created. Validation results are used to revise and improve product effectiveness, by including the opinions of media experts and material experts. After product validation, limited trials and field trials are carried out. A limited trial was carried out with a small class to assess the readability and usability of the mathematics E-worksheet. The results become the basis for product revisions before field trials are carried out. Field trials were carried out in two classes, experimental and control, to see the increase in students' critical thinking abilities.

The fourth stage is dissemination, this is the final stage, where the revised Mathematics E-worksheet product is distributed to teachers and students through scientific articles and providing access via gadgets. The distribution process involves collaboration with teachers and students from the middle school where the trial was conducted.

Two types of trials, namely limited trials and field trials, are carried out as part of the product trial design. The limited trial aims to test the readability and response of students to PBL-based E-worksheet as well as empirically testing the question instrument involving 30 students from class VIII. Data analysis from these trials is used to improve or revise the product. Field trials use a one group approach with one trial class. Students learn in traditional ways before using E-worksheet products. Increasing critical thinking skills is evaluated through increasing test results (gain) from the pre-test and post-test. Products are considered practical and effective if they can improve students' critical thinking skills. The trial design can be seen in Table 1.

Table 1. Trial Design

Pretest	*Treatment*	*Posttest*
O_1	X	O_2
O_1	-	O_2

Information:
X = Application of learning media
O_1 = Pre-Treatment Test
O_2 = Post-Treatment Test
In field trials, several important things to pay attention to include:

The pretest and posttest are used to measure students' critical thinking abilities, with an essay test consisting of 8 questions.
The increase between pretest and posttest is an indicator of the development of students' critical thinking abilities.

PBL-based E-worksheet is considered practical and efficient if it can improve students' critical thinking skills. A comparison between the experimental class (which uses E-WORKSHEET) and the control class (which uses PowerPoint) will show whether learning media has an effect on the development of critical thinking skills. The implementation of learning between the two classes is not that different. Both carried out a pretest and posttest and followed a learning plan that had been adapted for research, with 3 meetings per class. The difference lies in the use of E-WORKSHEET by the experimental class and PowerPoint by the control class in core learning activities.

The test subjects were class VII students at SMP Muhammadiyah 25 Paciran in the even semester of the 2022-2023 academic year. A total of 30 students from class VII and 30 students from class VIII were the subjects of limited trials and empirical trials. Field trial subjects were selected from all class VII and consisted of one class with 30 students. Data collection techniques include interviews with mathematics teachers and students, observations of school conditions and student learning environments, and the use of questionnaires. Questionnaires are used to validate E-WORKSHEET products by media and material experts, readability of E-WORKSHEET by students, student responses to the use of E-WORKSHEET, and validation of critical thinking ability test items. Critical thinking ability tests are used to assess students' critical abilities. Research instruments include interview guidelines and research documentation.

All instruments used in this research have been validated by experts using valid/invalid questionnaires accompanied by comments and suggestions for improvement. Validation was carried out on instruments such as interview guides, observation sheets, Mathematics E-WORKSHEET validation sheets, validation sheets for critical thinking ability test items, product readability questionnaires, and student response questionnaires. The critical thinking ability test instrument was validated using a valid/invalid questionnaire equipped with comments and suggestions for improvement, as well as through empirical testing of questions. The results of empirical tests on critical thinking skills were analyzed using the SPSS program. Reliability analysis of critical thinking ability test instruments was carried out using classical theory using the Quest program. The criterion for determining reliability is ≥ 0.7. The quantitative data resulting from the analysis is then converted into categories to determine the reliability assessment by Arikunto (2013: 115) as seen in Table 2.

Table 2. Reliability Assessment Categories

Reliability Coefficient	Category
r ≤ 0,20	Very Low
0,20 ≤ r < 0,40	Low
0,40 ≤ r < 0,70	Medium
0,70 ≤ r < 0,90	High
0,90 ≤ r < 1,00	Very High

Data Analysis of Readability Results for Mathematics e-worksheet Learning Media. The readability of the E-WORKSHEET Mathematics learning media by students can be determined through a questionnaire. The answer choices on the questionnaire are "YES" and "NO". The data obtained through the questionnaire is quantitative data which is then calculated into percentage form using the following equation.

$$\textbf{Readability results} = \frac{\textbf{Amount ticked "YES"}}{\textbf{total number of items}} \times 100$$

The percentage of readability results that are still in the form of quantitative data are then converted into qualitative or categorical data (Widoyoko, 2013: 110) which can be seen in Table 3.

Table 3. Conversion of Percentages into Categories

Percentage	Category
$80 < x \leq 100$	Very Good
$60 < x \leq 80$	Good
$40 < x\ 60$	Enough
$20 < x \leq 40$	Not enough
$0 < x \leq 20$	Very Not Enough

The questionnaire results from assessing media suitability and student responses were analyzed using descriptive analysis. Qualitative data from Likert's statements are converted into quantitative data on scale 4. Next, the conversion data is classified into actual score groups which reflect the level of product feasibility. Classification is carried out based on comparison with the average ideal score and ideal standard deviation as determined by Mardapi (2008).

Table 4. Categories of Score Conversion

No.	Intervals	Category
1.	$M + 1{,}55D < X$	Vey Worthy
2.	$M + 0{,}55D < X \leq M + 0{,}55D$	Worthy
3.	$M - 0{,}55D < X \leq M + 0{,}55D$	Quite Worthy
4.	$M - 0{,}55D < X \leq M - 0{,}55D$	Unworthy
5.	$X \leq M - 0{,}55D$	Very not Worthy

Information:
M is the average ideal score = ½ (maximum score + minimum ideal score)
SD is the standard deviation value measured by 1/6 (ideal maximum value – ideal minimum score).

The minimum product suitability value for category “C” was determined in this investigation. This shows that the validator believes the product created is suitable for use as

a teaching aid. Data Analysis Improves Critical Thinking Ability. By using pretest and posttest, the development of students' critical thinking skills is evaluated. Standard gain is a quantitative measure used to express pretest and posttest results. By using the following equation, we can determine the standard gain (g). The standard gain scores were then classified into high, medium and low (Hake, 1999: 1) which can be seen in Table 5.

Table 5. Gain Value Criteria

Score (g)	Classification
g ≥ 0,7	High
0,7 > g ≥ 0,3	Medium
g < 0,3	Low

This development research resulted in (1) An E-WORKSHEET which has a Problem Based Learning (PBL) base with an orientation towards the skills of junior high school students to think critically on Social Arithmetic material, (2) Validation of media and material experts on PBL-based E-WORKSHEET with oriented towards critical thinking skills, (3) Responses and assessments consisting of one-on-one trials and small group trials on the E-WORKSHEET, and (4) Results of effectiveness tests from junior high school students on Social Arithmetic material that has been produced and tested in the form of pre- and post-treatment tests.

The process of developing EdPuzzle-based Mathematics E-WORKSHEET with a PBL approach begins with the Define stage, where an analysis of teacher and student needs is carried out. The results of interviews with teachers show that although school facilities and infrastructure are adequate, there are still deficiencies in the effective use of learning media. Teachers have tried to use learning tools and media, but there are still weaknesses in attracting students' attention and explaining concepts adequately. Meanwhile, distributing questionnaires to students shows that they have access to technology such as computers and smartphones, and prefer learning with interactive media.

The Design stage involves designing learning media which includes developing PBL-based E-WORKSHEET using Microsoft Word and Flipbuilder. The material is prepared based on the school curriculum and learning principles, with the addition of relevant examples and videos. Flowcharts and storyboards are created to simplify the design process, while evaluations are carried out to ensure design quality.

Thus, the E-WORKSHEET development process aims to meet the needs of teachers and students in learning Social Arithmetic by providing interactive learning media based on PBL and combining audio, visuals and access flexibility. A material expert, Nur Robiah Nofikusumawati Peni, S.Pd., M.Ed., Ph.D. in Ed, Lecturer at Ahmad Dahlan University (UAD) Yogyakarta, validating the E-WORKSHEET material used in this research. The content and objectives of the verified materials are of high quality, and also have instructional quality features. Table 6. below displays the validation results.

Based on table 6, it is known that the content and objective quality aspects have a total assessment value by material experts of 63 and are classified or categorized as very appropriate. Apart from that, the instructional quality aspect has a final score of 71 and is categorized as very decent. Overall, the E-WORKSHEET material that has been assessed by material experts received a score of 134 and was declared very appropriate.

Table 6. Material Expert Validation Results

Aspect	Score	Category
Quality of Content and Purpose	63	Very Worthy
Instructional Quality	71	Very Worthy
Total	134	Very Worthy

Nur Robiah Nofikusumawati Peni, S.Pd., M.Ed., Ph.D., Lecturer at Ahmad Dahlan University (UAD) Yogyakarta validated the LKPD media used in this research as a media expert. There are eight aspects in this media assessment. Table 7. below displays the validation results.

Table 7. Media Expert Validation Results

Aspet	Score	Category
Content Quality	19	Very Worthy
Design Suitability	14	Very Worthy
Motivation	4	Very Worthy
Design Drawing	38	Very Worthy
Instructions for Use	19	Very Worthy
Accessibility	14	Very Worthy
Use	17	Very Worthy
Standard Adjustment	5	Very Worthy
Total	130	Very Worthy

PBL-based Mathematics e-worksheet has been developed through several stages of revision and testing. The final product is a .swf file that can be accessed via the FlipBuilder platform. This E-worksheet displays Social Arithmetic material in the form of practical instructions and videos, enabling practical practice for students. Available navigation features make it easy to access and use, while interactive learning provides immediate feedback and the opportunity to adjust thinking.

The results of the analysis show that the e-worksheet is suitable for use for learning, with worksheets that are appropriate to the students' learning objectives. In addition, the results of field trials show an increase in students' critical thinking abilities. e-worksheet is effective because it encourages involvement, provides feedback, and facilitates collaboration among students. Active learning strategies such as problem-based learning and project-based learning have been included in this e-worksheet to improve critical thinking skills. With the use of technology, e-worksheet can provide access to various resources and tools for analyzing, evaluating and synthesizing information, as well as facilitating collaborative learning.

RESULTS AND DISCUSSION

E-worksheet mathematics assisted by EdPuzzle with a PBL approach was declared feasible and effective for improving the critical thinking skills of class VII students at SMP Muhammadiyah 25 Paciran. Validation by material experts and media experts shows the category is very feasible. Student responses to E-WORKSHEET are also very good. In addition,

the n-gain value from pre-test to post-test reached 84.04%, which shows a high increase in critical thinking skills.

Suggestions for further development of this learning media include: Teachers and students can use this E-WORKSHEET inside and outside the classroom, taking advantage of its accessibility via various devices, Teacher direction is needed to build a discussion climate that encourages student participation when using E-WORKSHEET, and It is recommended to expand the scope of the research by involving more classes or schools as a continuation of the research, including considering the use of control classes for better comparison.

CONCLUSION

Based on the presentation of the data and analysis in the previous chapter, the results of the research on the development of Mathematics E-WORKSHEET assisted by EdPuzzle with a PBL approach concluded that the E-WORKSHEET Mathematics assisted by EdPuzzle with a PBL approach was declared suitable for use to improve the critical thinking skills of class VII students at Muhammadiyah Middle School. 25 Paciran based on material expert assessment based on aspects of content quality and objectives and instructional quality aspects obtained validation results in the very feasible category. validation results in the very decent category, students' responses to E-WORKSHEET with aspects of appearance, operation and linguistic aspects obtained very good scores. E-WORKSHEET Mathematics assisted by EdPuzzle with a PBL approach was declared effective in improving the critical thinking skills of class VII students at SMP Muhammadiyah 25 Paciran based on obtaining n-gain scores which were categorized as high with an increase of 84.04% from pre-test to post-test.

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DECLARATION

Author Contribution

All authors contribute in the research process, such as collecting the data, analyzing the data, and writing the manuscript. All authors approved the final manuscript.

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Conflict of Interest

Both authors declare that they have no competing interests.

Ethics Declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Emerging Mathematics Education (IJEME) in maintaining high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

REFERENCES

Acharya, B. R. (2017). Factors affecting difficulties in learning mathematics by mathematics learners. *International Journal of Elementary Education*, *6*(2), 8-15.

Aini, N. R., Syafril, S., Netriwati, N., Pahrudin, A., Rahayu, T., & Puspasari, V. (2019, February). Problem-based learning for critical thinking skills in mathematics. In *Journal of Physics: Conference Series* (Vol. 1155, No. 1, p. 012026). IOP Publishing.

Carmichael, M., Reid, A., & Karpicke, J. D. (2018). Assessing the impact of educational video on student engagement, critical thinking and learning. *A SAGE white paper*.

Caviglia-Harris, J. (2016). Flipping the undergraduate economics classroom: Using online videos to enhance teaching and learning. *Southern Economic Journal*, *83*(1), 321-331.

Oktavianingtyas, R., Trapsilasiwi, D., Murtikusuma, R. P., & A'yun, Q. (2020, February). Analysis of students' critical thinking skills on social arithmetics with jumping task. In *Journal of Physics: Conference Series* (Vol. 1465, No. 1, p. 012070). IOP Publishing.

Macías Rivas, M. P. (2012). *Stimulating critical thinking through mathematics word problems* (Bachelor's thesis, Educacion).

Miner-Romanoff, K., Rae, A., & Zakrzewski, C. E. (2019). A holistic and multifaceted model for ill-structured experiential problem-based learning: Enhancing student critical thinking and communication skills. *Journal of Problem Based Learning in Higher Education*, *7*(1).

Nadeak, B., & Naibaho, L. (2020). The Effectiveness of Problem-Based Learning on Students' Critical Thinking. Jurnal Dinamika Pendidikan, 13(1), 1–7.

Seibert, S. A. (2021). Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance. *Teaching and Learning in Nursing*, *16*(1), 85-88.

Sharadgah, T. A. Al. (2014). Developing critical thinking skills through writing in an internet-based environment. Society for Information Technology & Teacher Education International Conference, 2178–2185. Association for the Advancement of Computing in Education (AACE).

van Alten, D. C., Phielix, C., Janssen, J., & Kester, L. (2020). Self-regulated learning support in flipped learning videos enhances learning outcomes. *Computers & Education*, *158*, 104000.

Wale, B. D., & Bishaw, K. S. (2020). Effects of using inquiry-based learning on EFL students' critical thinking skills. *Asian-Pacific Journal of Second and Foreign Language Education*, *5*, 1-14.

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.

Zahroh, D. A., & Yuliani, Y. (2021). Pengembangan E-worksheet berbasis literasi sains untuk melatihkan keterampilan berpikir kritis peserta didik pada materi pertumbuhan dan perkembangan. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *10*(3), 605-616.

Zhou, Z. (2018). An Empirical Study on the Influence of PBL Teaching Model on College Students' Critical Thinking Ability. *English Language Teaching*, *11*(4), 15-20.

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