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Development of Electronic Mathematics Student Worksheets Assisted by Book Creators to Support Problem-Based Learning Models to Achieve Student Problem-Solving Ability

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Abstract: Electronic-based teaching materials are needed to carry out online learning so that education can run optimally. However, many schools still use printed teaching materials. This study aimed to produce mathematical student worksheet elektronik assisted by book creators to support valid, practical, and effective problem-based learning models to achieve problem-solving abilities. This research used a research and development (R & D) with ADDIE model. Based on the validity test results, media experts obtained an average of 3.82 with good standards, and material experts obtained an average of 4.44 with excellent standards. In addition, based on the results of the practicality test, the small group obtained an average of 3.98 with a good standard, and the large group obtained an average of 4.20 with a good standard. Based on the effectiveness test results, the results of completeness are obtained with a percentage of 90% of students achieving problem-solving. Therefore, this study was declared victorious in obtaining an e-LKPD development product with valid, practical and effective quadratic equation material. The developed e-LKPD was displayed as feasible for use in learning.

Keywords: Electronic student worksheet, book creator, problem-based learning, problem solving ability

1. Introduction

Mathematics is a field of study that teaches students how to think objectively, analytically, systematically, critically, and creatively and cooperate with others, starting from elementary school (Depdiknas, 2003). Mathematics is also defined as a tool to solve problems encountered in everyday life. Therefore, at all levels of education, mathematics learning is always taught (Riyanto & Gunarhadi, 2017). The objectives of learning mathematics are 1) Understanding mathematical concepts, describing their relationships, and using concepts or methods in problem-solving in a flexible, accurate, efficient, and consistent manner, 2) Applying pattern and characteristic reasoning, applying mathematical operations to make generalizations, accumulating evidence, or describing mathematical concepts and accomplishments, 3) Problem solving, which entails the capacity to comprehend problems, create mathematical models, solve models, and come up with answers, 4) Use symbols, diagrams, or other media to communicate mathematical principles to clarify situations or issues, 5) Having an attitude of appreciating the utility of mathematics in everyday life, an interesting interest and curiosity in learning mathematics, and a tenacious attitude and confidence in problem-solving (Depdiknas, 2006).

To achieve the objectives of mathematics learning, the teacher must help students optimally to understand mathematics learning well because mastering mathematical topics that have been thoroughly studied will enable students to understand the connections between various concepts in mathematics and the application of mathematics in everyday life. The National Council of Teachers of Mathematics (NCTM) proposed that children learn mathematics to develop five abilities: 1) problem solving, 2) reasoning and proofing, 3) communication, 4) connection, and 5) representation (NCTM, 2000). According to this notion, one of the mathematical abilities that pupils must possess is problem-solving ability. As a result, the focus of this research was solely on developing problem-solving skills.

Problem-solving ability is a goal of all mathematics topics, and it is even at the heart of mathematics learning (Darma et al., 2018). Solving problems entails some steps in the cognitive process, including acquiring and using knowledge and experience (Lester & Kehle, 2003). Because problem-solving requires knowledge and experience

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activities, students need to equip themselves with various skills that involve higher-order thinking processes (Abdullah et al., 2015). Based on data from the PISA (The Program For International Student Assessment) study in the category of mathematical ability from 2000 to 2015 (Kastberg et al., 2016).

Table 1. Mathematics PISA results for Indonesia from 2000 to 2015

Year of Study	Indonesia Average	International Average	Indonesia Ranking	Number of Study Participating Countries
2000	367	500	39	41
2003	360	500	38	40
2006	396	500	50	56
2009	371	500	61	65
2012	375	500	64	65
2015	386	500	63	69

As well as the study of TIMSS (Trend In International Mathematics And Science Stud) data in the mathematics category from 2003 to 2015 (Hadi & Novaliyosi, 2019).

Table 2. Results of TIMSS mathematics for Indonesia from 2003 to 2015

Year of Study	Indonesia Average	International Average	Indonesia Ranking	Number of Study Participating Countries
2003	411	467	35	46
2007	397	500	36	49
2011	386	500	38	42
2015	397	500	44	49

It can be seen in the findings and evaluations of PISA and TIMSS until 2015, showing that Indonesian students' mathematical abilities are still need to be improved. One of the factors that could cause students' low PISA and TIMSS results were students' low mathematical solving ability in learning. Students tend to be passive, primarily working on routine questions, and do not understand the meaning of the problems at hand (Astriani et al., 2017). Therefore, several developed countries were chosen to be examples of problem-solving skills in the mathematics curriculum in schools. Some of the countries selected were Singapore, Hong Kong, England, and the Netherlands (Anderson, 2009).

In applying problem-solving skills in learning mathematics in schools, we must understand more about the elements that affect students' problem-solving abilities by observing each indicator of problem-solving skills. Meanwhile, according to (Branford & Stein, 1993), there are five indicators of students' problem-solving ability, called the "IDEAL" model. This model implies 1) I-Identify problem, 2) D-Define goals, 3) E-Explore possible strategies, 4) A-Act on strategy, 5) L-Look back and evaluate the effects.

In addition, to achieve students' problem-solving abilities, teachers need effective learning strategies. Effective learning strategies can be in approaches, methods, techniques, or learning models. One type of learning recommended in achieving problem-solving skills is using a problem-based learning model (Mataka et al., 2014). The problem-based learning model is student-centered and encourages students to develop problem-solving skills (Ajmal et al., 2016). Because the problem-based learning model focuses on students, this model can produce more effective and innovative learning (Harahap, 2017). In the problem-based learning model, there are five syntaxes adapted from (Hu et al., 2018), namely: 1) Problem orientation, 2) Organizing students, 3) Guiding individual/group investigations, 4) Developing and presenting achievements, 5) Analyze and evaluate problem-solving.

Based on the result of interview with mathematics teacher at Junior High School No. 1 Muhammadiyah, Mlati regarding the characteristics of students in learning mathematics, the teacher said that the characteristics of students during the learning process were two conditions. Namely, some students felt enthusiastic and passionate when learning mathematics, but most of them still felt mathematics was a complex subject, thus the students were less active. Likewise, regarding problem-solving skills, most students did not yet have them. This could be observed based on the evaluation of students' mathematics learning outcomes. Based on the assessment of student learning outcomes, students still got scores below the minimum standard of completeness criteria. In addition, the teacher also said that online learning conditions caused teachers experience problems in assisting students' learning process, making it difficult to detect whether students have understood or not from the material presented.

On the other hand, students also experienced obstacles in online learning. Due to the limited interaction between students and teachers, students must have been independent in mastering learning topics. This makes it difficult for students because students have been guided face-to-face learning so far. Observing the current situation in Indonesia during the Covid-19 pandemic, as a result, the learning system was carried out online through a virtual room. Therefore, electronic-based teaching materials are needed to facilitate the implementation of online teaching and learning, including electronic student worksheets.

However, in today's online learning, teaching materials used in schools are still printed teaching materials, including student worksheets. Teachers have not used electronic student worksheets in learning as an online learning facility. The existing student worksheets are also still simple, so they have not been able to achieve the overall problem-solving ability of students. In connection with this, the purpose of this study was to determine the making of electronic mathematics student worksheets assisted by book creators as support for problem-based learning models to achieve student problem-solving abilities and to know the validity, practicality, and effectiveness of electronic mathematics student worksheets assisted by books creator as a supporter of the problem-based learning model to achieve student problem-solving abilities.

2. Literature Review

2.1 Electronic Student Worksheet

Student worksheets are guidelines for carrying out learning activities and completing exercise sheets (Inan & Erkus, 2017). Student worksheets are designed to assist students in problem-solving by connecting issues with real-world situations (Yaden, 2017). At the same time, the electronic student worksheet has the same function as the usual student worksheet. Because it is electronically based, the student worksheets are completed digitally and can be accessed via the internet. The way to use it is the same as using an electronic module, accessed via desktop computers, notebooks, smartphones, and mobile phones (Handayani et al., 2021). Therefore, electronic student worksheets are teaching materials in the form of student worksheets in digital format that can be accessed via the internet and can be designed according to the objectives to be achieved to facilitate learning activities that enable the teaching and learning process.

2.2 Problem Solving Ability

One of the most challenging levels of cognitive activity for an individual is the problem-solving ability. This is because problem-solving skills require efforts that involve all of the person's intellectual abilities (Hobri et al., 2020). According to the National Council of Teachers of Mathematics (NCTM), problem-solving is an essential component of successful learning and a secondary goal of learning mathematics. Students who lack problem-solving skills will not be able to handle the challenges they will face (NCTM, 2000). With the problem-solving skills they have, students can develop their thinking capacity. Students will be able to understand the problem well and develop the ability to solve a problem. Therefore, developing students' problem-solving skills in mathematics is the leading way to help them understand problems and how to solve them (Bayuningsih et al., 2017).

2.3 Problem-Based Learning Model

The problem-based learning paradigm is a teaching method in which students solve real-world problems to build their knowledge, develop inquiry and higher order thinking skills, and gain independence and self-confidence (Arends, 2004). Applying problem-based learning stimulates students' minds and directs their attention (Nurtanto et al., 2020; Haryani et al., 2017; Phungsuk et al., 2017). As a result of the learning process, the use of problem-based learning models in the classroom can inspire, challenge, and delight students in the implementation of learning (Norman & Schmidt, 2000).

3. Methodology

This research involved product development using e-LKPD mathematics with a problem-based learning model to achieve students' problem-solving abilities in this study using a research and development (R & D) with ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Aldoobie, 2015).

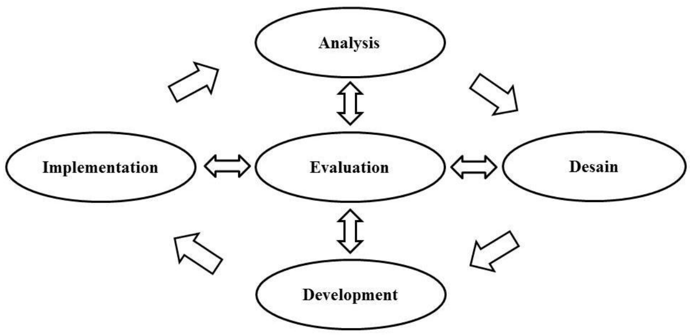

Fig. 1. ADDIE Model

The subjects in this study were students of Junior High School No. 1 Muhammadiyah, Mlati class IX with 26 students. The data collection instruments were 1) Non-test instruments, including e-LKPD assessment questionnaires by material experts, media experts and student responses, documentation and interviews, 2) Test instruments include problem-solving ability test questions with 4 types of descriptions.

Data analysis techniques were used to determine product quality, such as validity, practicality, and effectiveness, namely changing quantitative information into qualitative information.

Table 3. Conversion of quantitative data to qualitative data

Score Range	Qualitative Criteria
$\bar{X} > \bar{X}_i + 1.80\ SB_i$	Excelent
$\bar{X}_i + 0.60\ SB_i < \bar{X} \leq \bar{X}_i + 1.80\ SB_i$	Good
$\bar{X}_i - 0.60\ SB_i < \bar{X} \leq \bar{X}_i + 0.60\ SB_i$	Good enough
$\bar{X}_i - 1.80\ SB_i < \bar{X} \leq \bar{X}_i - 0.60\ SB_i$	Not good
$\bar{X} > \bar{X}_i - 1.80\ SB_i$	Very not good

Then proceed with data analysis of validity and practicality. The validity data came from the findings of the material expert and media expert questionnaires. In contrast, the practicality data came from the student response questionnaires for the small class trial and the large class trial. The product was said to be valid and practical if the average score obtained is at least within the "Good" criteria.

Table 4. Ideal assessment criteria for material experts, media experts and student response questionnaires

Score Range	Criteria
$\bar{X} > 4{,}20$	Excelent
$3{,}40 < \bar{X} \leq 4{,}20$	Good
$2{,}59 < \bar{X} \leq 3{,}40$	Good enough
$1{,}79 < \bar{X} \leq 2{,}59$	Not good
$\bar{X} \leq 1{,}79$	Very not good

Then, the effectiveness data were obtained based on individual mastery and classical completeness results obtained from the effects of students' problem-solving ability tests in large group trials. Individual completeness was calculated based on the following formula.

$$PI = \frac{Total\ correct\ score}{Maximum\ score} \times 100\% \quad (1)$$

Meanwhile classical completeness was calculated based on the following formula.

$$PC = \frac{Number\ of\ students\ who\ completed}{Total\ number\ of\ students} \times 100\% \quad (2)$$

Furthermore, the PK value of students' mathematical problem-solving abilities is categorized based on the criteria (Arikunto, 2010).

Table 5. Criteria for complete learning

Percentage of Completeness (%)	Criteria
$PK \geq 80$	Excelent
$60 \leq PK < 80$	Good
$40 \leq PK < 60$	Good enough
$20 \leq PK < 40$	Not good
$PK < 20$	Very not good

Product development was said to be effective in achieving problem-solving abilities if the percentage of completeness on the students' post-test results reaches a minimum completeness value in the "Good" category with an average value above the minimum completeness criteria.

4. Results

At this stage of analysis, several analysis results were obtained, namely: 1) students' problem-solving ability had not been achieved. 2) The available LKPD had not been able to assist students in achieving problem-solving abilities. 3) The material for quadratic equations was material that was considered difficult by students in odd semesters.

At the design stage, researchers designed the e-LKPD in the form of preparing a learning program step that integrated five problem-based learning syntaxes, including: 1) Student orientation to problems, 2) Organizing students,

3) Guiding individual/group experiences, 4) Develop and present the work, 5) Analyze and evaluate the problem-solving process. And indicators of problem-solving abilities include: 1) Identifying problems, 2) Determining goals, 3) Strategizing strategies, 4) Implementing strategies, and 5) Looking back and evaluating the results. Then was proceed with the preparation of a learning framework which included several sections on the e-LKPD: cover display, identity page, foreword display, table of contents display, instructions display, competency display, concept map display, prerequisite material display, evaluation display, and list references.

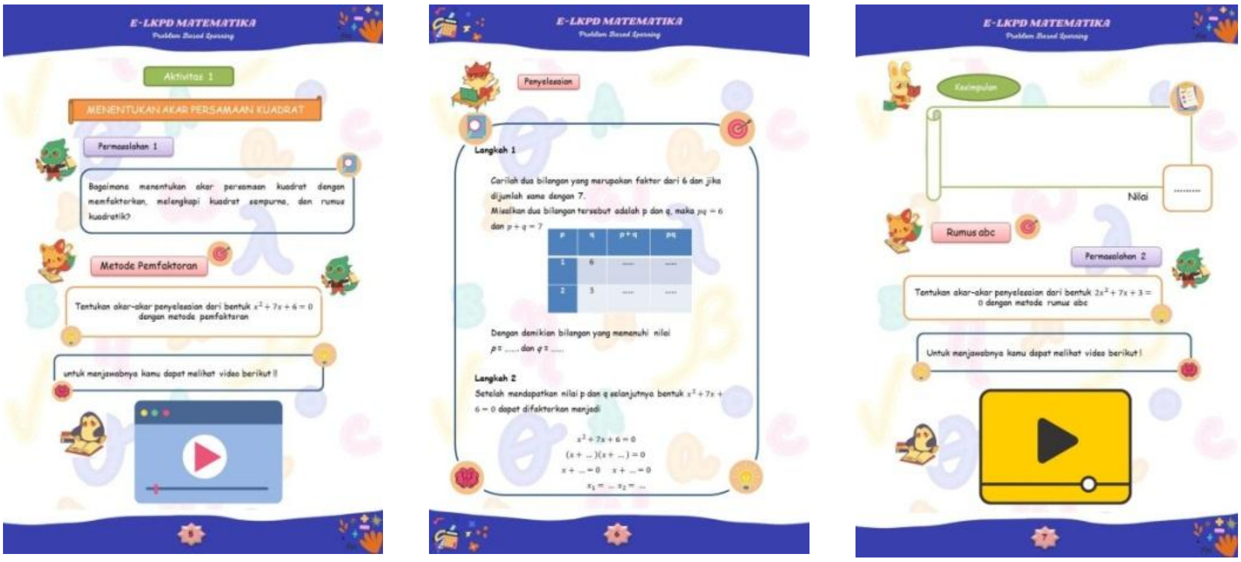

Fig. 2. Design of E-LKPD according to PBL syntax

At the development stage, the process of making e-LKPD was carried out on the book creator application. Then was proceeding with e-LKPD validation by media experts, which includes: aspects of appearance, layout, e-LKPD design, and illustrations.

Table 6. Results of media expert validity data

No.	Validator	Average	Criteria
1.	Media expert 1	3.88	Good
2.	Media expert 2	3.76	Good
Average total score		3.82	Good

Based on the table above, it could be seen that the average validity of the media expert data results is 3.82. This showed that the developed e-LKPD had been declared "Valid" with good criteria by media experts. At the same time, the validation of e-LKPD by material experts included aspects of content feasibility, presentation feasibility, language and conformity with the PBL model.

Table 7. Results of material expert validity data

Number	Validator	Average	Criteria
1.	Material expert 1	4	Good
2.	Material expert 2	4.88	Excelent
Average total score		4.44	Excelent

Based on the table above, it could be seen that the average validity of the material expert data results is 4.44. This showed that the developed e-LKPD had been "Valid" with excellent criteria by material experts. At the implementation stage, the e-LKPD that had been declared valid was then implemented to students directly to get the results of the practicality test. e-LKPD was implemented in two groups, namely small groups and large groups.

Table 8. Average score of small group and large group

Group	The number of students	Average score	Criteria
Small	6	3.98	Good
Large	20	4.20	Good

The results of the student response questionnaire from the small group got an average score of 3.98, and the large group gained an average of 4.20. This value was included in the good category so that it could be said that e-LKPD is declared “Practical”.

In the evaluation stage, at this stage, the researcher gave a post-test to determine the effect of learning on the product being developed. After the post-test results were obtained, to test the developed product's effectiveness, the researchers analyzed the achievement of students' problem-solving results based on individual mastery and classical mastery. Based on the results of individual completeness, it was found that there were 18 out of 20 students achieved scores above the KKM. In other words, the classical completeness obtained is 90% of the total class population that is declared complete.

Tabel 9. Achievement of problem-solving ability results

Students Code	Posttest
UB. 01	84
UB. 02	76
UB. 03	70
UB. 04	64
UB. 05	71
UB. 06	84
UB. 07	73
UB. 08	85
UB. 09	73
UB. 10	72
UB. 11	71
UB. 12	77
UB. 13	71
UB. 14	72
UB. 15	62
UB. 16	72
UB. 17	82
UB. 18	78
UB. 19	82
UB. 20	74
Total Score	1494
Average	74.65

Therefore, based on the results of the effectiveness test, it can be concluded that the use of e-LKPD problem-based learning in learning mathematics on quadratic equation material is declared "Effective".

5. Discussion

In developing the product, the researchers created a comprehensive e-LKPD framework, namely completing e-LKPD starting from the presentation of material, learning videos, evaluation questions, answer keys, and adding problem-based learning and problem-solving ability indicator symbols. The material in the e-LKPD was arranged with the stages of a problem-based learning model. The researcher also developed an assessment instrument and student questionnaire at this stage. The researcher used the teacher's book and the revised grade 9 mathematics student book to prepare the material. The material was first compiled using Microsoft PowerPoint before being entered into the e-LKPD. Then for the learning videos that would be included in the e-LKPD taken via YouTube, the videos were selected according to the material needed in achieving student competence. The evaluation questions and answer keys were based on several references to mathematics books and websites. Meanwhile, symbols representing problem-based learning and KPM indicators were edited through the Canva application.

After the e-LKPD framework was completed, the researchers carried out the process of making e-LKPD using the book creator application. Still, before that, the researchers used the Canva application to design the cover and content of the e-LKPD so that the display was more attractive because the editing design facilities in the book creator application were still relatively simple. After the e-LKPD with the problem-based learning model was completed in the book creator, the e-LKPD was published to get an access link when it was about to be used in learning.

Next, the researcher validated the media experts and material experts. Based on the assessment results by the media expert validator, the validity result was 3.82 with good criteria and was declared "Valid".

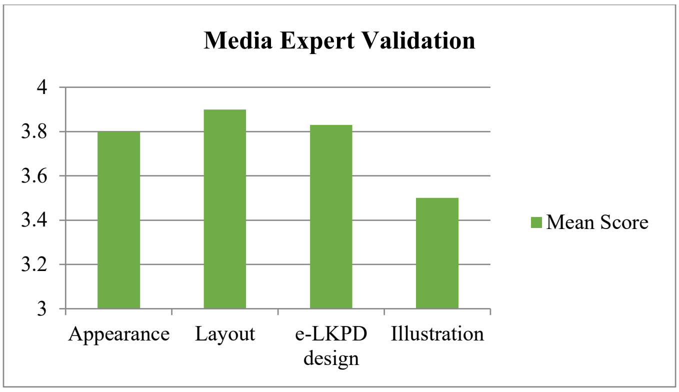

Diagram 1. Media expert validation results

Based on Diagram 1, the highest average score was obtained from the layout aspect with an average of 3.9. This shows that the layout arrangement in the e-LKPD was appropriate and suitable. At the same time, the lowest average score was obtained in the illustration aspect, with an average of 3.5. This is because the validator considers that the illustrations depicted do not follow the development of the student's age.

As for the assessment of the material expert validator, the results obtained are 4.44 with excellent criteria and declared "Valid."

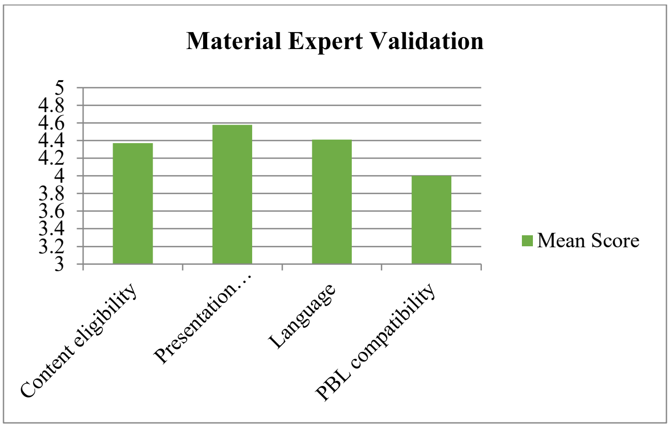

Diagram 2. Material expert validation results

Based on Diagram 2, the highest average score is obtained from the aspect of presentation feasibility with an average of 4.58. This shows that in terms of presenting e-LKPD, it is perfect. Meanwhile, the lowest average score was obtained in the suitability aspect of problem-based learning with an average of 4. The validator comments on the suitability aspect of problem-based learning said that "because e-LKPD uses problem-based learning, problem orientation should contain more problems in everyday life day, but in e-LKPD, there are still materials that do not contain daily problems".

After the e-LKPD had been declared valid, it was implemented directly to students by testing it in two groups: small and large groups. The results of the student response questionnaire from the small group got an average score of 3.98 with good criteria and were declared "Practical".

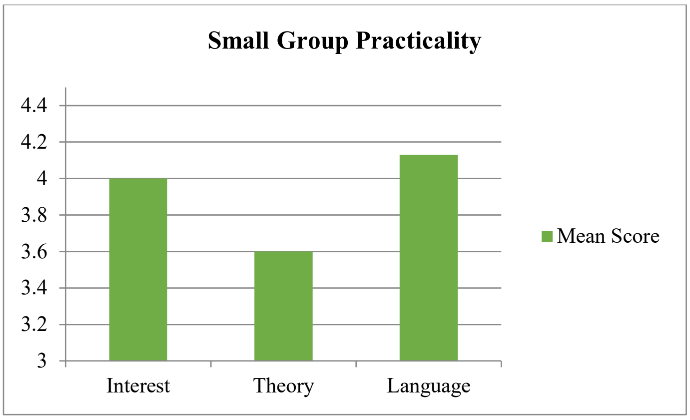

Diagram 3. Practical results of small-groups

Based on the three components of the student response questionnaire assessment in small groups, it could be concluded that the highest score was obtained from the language component with an average of 4.13, and the lowest score was obtained from the material component with an average of 3.6. While in the large group trial, the results of the student response questionnaire were obtained with an average of 4.20 with good criteria and declared "Practical".

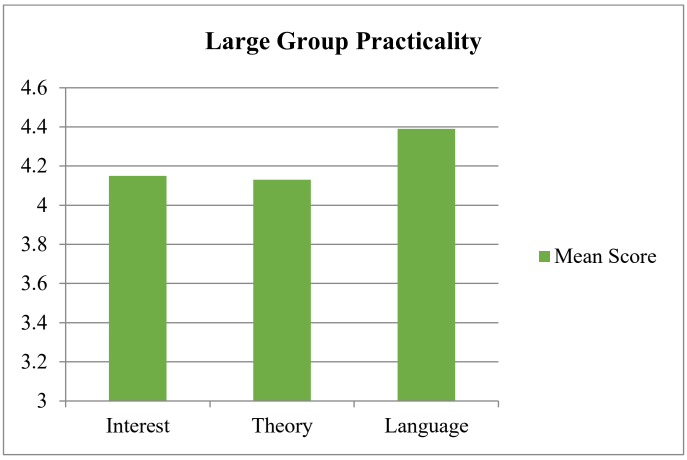

Diagram 4. Practical results of big-groups

Based on the three components of the student response questionnaire assessment in large groups, it can be concluded that the highest average score was obtained through the language component with an average score of 4.38, and the lowest score was obtained through the material component with an average score of 4.13.

From the results of practicality in small groups and large groups, it can be seen that there is an increase in the average score for each component of the assessment. As seen from the results of the evaluation of small groups and large groups, the language component is the component that gets the highest average score. This shows that the language used in the e-LKPD is by the development of students so that it is easy to understand. At the same time, the material component is the lowest. Based on student comments on the questionnaire sheet, some students said that the material presented and some questions were quite tricky.

After the e-LKPD developed was used for learning and declared practical. In the next stage, the researcher gave post-test questions to determine the effect of the learning process on the product being developed. After the students' post-test results were obtained, the researchers analyzed the achievement of students' problem-solving abilities to test the products' effectiveness. Based on the results of the post-test analysis of problem-solving abilities, it was found that 90% of the total class population was declared complete. These results are in the very good category. Based on the effectiveness test results, it can be concluded that using e-LKPD problem-based learning in learning mathematics on quadratic equation material is "Effective" for learning.

Table 10. Achievement results of the problem-solving ability indicator

Indicator	Percentage of Student Achievement (%)	
	Yes	No
Identification of problems	98.12	1.88
Setting Goals	53.75	46.25
Designing Strategy	78.12	21.88
Implementing Strategy	78.12	21.88
Check Back and Evaluate	41.88	58.12

Based on the Table 10, the percentage of achievement of learning outcomes is obtained based on each indicator of problem-solving ability. The table shows that the highest achievement was obtained through the problem identification indicator with a student percentage of 98.12%, followed by the indicator of designing strategies and implementing strategies with a student percentage of 78.12%. At the same time, the lowest indicator is obtained through indicators of determining goals and re-checking and evaluating with the percentage of students 53.75% and 41.88%. More details can be seen in the following diagram.

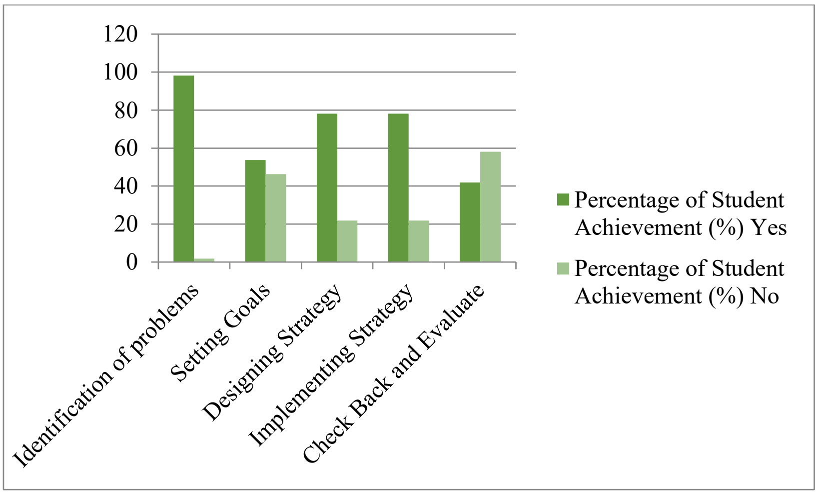

Diagram 5. Percentage of problem-solving ability results

From Diagram 5, it can be seen that some students are unattainable in the indicators of determining goals and indicators checking and evaluating the results. The reason for the failure of some students to set goals and review and assess the effects is because they only focused on completing answers, without paying attention to the completion steps, so they often forgot to write down what was asked of the questions and forgot to conclude the answers.s. This shows that students are not used to solving problems with steps.

6. Conclusion

This research was conducted to create teaching materials in the form of developing electronic student worksheets presented through the Book Creator application. Electronic student worksheets were designed by integrating problem-based learning models to achieve student problem-solving abilities in the development process. Then the electronic student worksheets that had been developed were revised based on input and suggestions from the validators, namely: media experts with an average validity score of 3.82 with good criteria and material experts with an average validity score of 4.44 with excellent criteria. After the electronic student worksheets were declared valid, then practicality tests were carried out by students: small groups with an average practicality score of 3.98 with good criteria and large groups with an average practicality score of 4.20 with good criteria. After the electronic student worksheets were declared practical, students who use the electronic student worksheets were given post-test questions to obtain the results of the effectiveness of the electronic student worksheets. Based on the results of the post-test analysis, the percentage of student learning outcomes completeness is 90%. Therefore, this study was declared victorious in obtaining an electronic student worksheet development product with valid, practical and effective quadratic equation material. The developed electronic student worksheet was displayed as feasible for use in learning.

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Conflict of Interest

The authors declare no conflicts of interest.

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