ICT-Based Learning Media to Enhance Students' Problem Solving Ability in Efforts to Face the Industrial Revolution 4.0

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Abstract. This study aimed to describe the feasibility of ICT-based learning media to improve student's abilities in mathematical problem solving to face the industrial revolution 4.0. This research developed by four D method, consist of define, design, develop and disseminate. The stages include analysis of potential and problems, the formulation objectives of the research, preparation of research instruments and learning media design, validation and revision of learning media, and implementation. Product trials were conducted in two different classes. The results showed that ICT based learning media were valid for use, in terms of the results from media expert validation. ICT-based learning media also meet practically and effectiveness for use in learning mathematics and can improve students' problems-solving ability, reviewed from evaluation tests that were developed show the results that students who use ICT-based learning media have better problem solving skills.

1. Introduction
Mathematics is a science that can help students to solve problems in daily life [10]. Problem-solving ability is very useful in life so that each country integrates mathematics as one of the mandatory lessons in school [3]. Many benefits of learning mathematics, does not make mathematics an interesting subject for students. Mathematics is a subject that is not interested in most students because students feel mathematics more difficult to learn[12]. Students' problem-solving abilities in mathematics are still at a low category in Indonesia ([7], [12], [11]). Problem-solving ability is one of learning mathematics goals, so it is important to develop mathematics learning to improve students' problem-solving abilities. One way to improve mathematical problem solving-skills is used media in mathematics learning, such as ICT [2].

The use of ICT-based media in learning can improve the quality of learning and improve the quality of education [14]. The use of ICT in education is also recommended [17] because it can improve achievement. Therefore, the use of ICT media is a positive thing in learning, and it is necessary to develop more ICT-based learning media that meet practical, effective, and efficient criteria to be able to visualize mathematical concepts more effectively to students. Through ICT-based learning media, students can be more actively involved in learning and develop students' abilities further, because with the support of technology students can be involved in the use of learning strategies to improve students' thinking abilities and better at understanding concepts [13].

Student’s ability to understand a concept also supports students' ability to solve mathematical problems. This is in line with research conducted by [5] who found that understanding concept by students who are accustomed to using realistic problem-solving skills are better than those that only
use conventional methods. When students are accustomed to critical thinking and actively, they can also be more effective in solving problems [9].

The ability to solve problems is the ability to get the right decision to complete its objectives through systematic stages. According to [4], students’ problem-solving abilities can be improved through student-centered learning. By learning to solve problems in mathematics, students should acquire ways of thinking, the habit of persistence and curiosity, and confidence in unfamiliar situations that will serve them outside the mathematics class [8]. By using ICT-based learning media designed to improve problem-solving skills, students can play an active role in the learning process compared to conventional learning and can be an alternative solution to improve problem-solving skills that are still low [13].

Maryam, et al [6] also revealed that the problem-solving process in learning is one of the important elements for students to practice problem-solving in real life. The ability to solve problems in real life is needed by students in the era of the industrial revolution 4.0 as it is today because the ability to think critically and solve problems can help in understanding and solving problems they face, and it is included in the 4-C ability (Communication, Collaboration, Critical Thinking & Problem Solving, and Creativity and Innovation) which is a mandatory abilities in the era of the industrial revolution 4.0. Problem-solving skills relating to the real world can be integrated to solve problems and competition in the real world as well. In other words, if a student is trained to solve a particular problem, the student has good skills in producing the right information, analyzing information and can improve the quality of the possessed resources.

Highly quality and highly competitive human resources are needed in the era of the industrial revolution 4.0 like today, so it must be prepared through quality education to produce a generation that can face global competition. Referring to this problem, research was conducted on the development of ICT-based learning media to improve students’ problem-solving abilities in effort facing the industrial revolution 4.0.

2. Method
This research was a type of research and development (RnD). According to [15], Research and Development is a research method used to produce certain products, and test the effectiveness of these products. The product of this research was ICT-based interactive multimedia to improve problem-solving abilities in the effort to deal with the industrial revolution 4.0. This media development uses a 4-D development model that was defined, design, develop, and disseminate. The subjects of this study were students of the eleventh class of SMKN 1 Wonoasri.

The research instruments being used were instrument validation sheets, media validation sheets, sheets, student questionnaire response sheets, and evaluation test questions sheets. Data collection techniques through observation, interviews, questionnaires, and tests. After the data was collected and tested, an analysis was carried out to determine the level of media validity, the practicality of the media, and the effectiveness of the media.

2.1. Define
Define aims to identify potential and problems, data collection, and the formulation of learning objectives.

2.2. Design
Activities at the design stage include the preparation of test instruments, media selection, and preliminary design of instructional media. The test instruments used in this study were the validation sheets of media to measure the level of media validity, the student response questionnaire sheets to measure the practicality of media, and the evaluation test questions to measure the effectiveness of media.
2.3. Develop
This stage aims to determine the weaknesses and strengths of a product that has been developed and consider making the final product. That is design validation, design revisions, and product trials.

2.4. Disseminate
This final stage includes three phases, namely product testing, packaging, and diffusion and adoption. If the development test shows consistent results and gets a positive rating and is declared valid for use in learning.

![Flowchart of the development model](image-url)

**Figure 1.** The flow of development model [15]
Product trials were conducted to find out whether the product being developed was better than the existing product. Experiments carried out by comparing the experimental group and the control group. Groups that taught using ICT-based interactive multimedia were called experimental groups, while groups without the use of ICT-based interactive multimedia were called control classes.

To test the appropriateness of media that was appropriate to be used as a learning medium, it was necessary to analyze the data which included validation, practicality, and effectiveness analysis. Validity analysis was done by assessing every aspect of the media by the validator using a range of values 1 to 4. The formula used to process the validation data stated as follows:

\[ V = \frac{T_{se}}{T_{sh}} \times 100\% \]  

Note:  
\( V \) = Percentage of validity  
\( T_{se} \) = total empirical score (total score scored by the validator)  
\( T_{sh} \) = Total expected score

The overall percentage with three validators can be found using the average formula as follows:

\[ V = \frac{V_1 + V_2 + V_3}{3} = \ldots \% \]  

The developed media is declared valid if the combined validity results show more than 70% [1]. However, if there are suggestions for improvement, researchers do design improvements before further development. Practicality analysis was obtained from the student response questionnaire. The recapitulation of scores from the questionnaire is then calculated to get a presentation using the following formula:

\[ P = \frac{A}{B} \times 100\% \]  

Note:  
\( P \) = Percentage of student responses  
\( A \) = Total number of scores obtained  
\( B \) = Total ideal score (criteria)

The developed media can meet the practicality criteria of the media if the percentage is more than 70%. The effectiveness analysis was carried out from looking at the percentage of test results of learning after using learning media. To determine the completeness of student learning can be calculated by the formula:

\[ KB = \frac{T}{T_t} \times 100\% \]  

Note:  
\( KB \) = Percentage of mastery learning  
\( T \) = Number of scores obtained by students  
\( T_t \) = Total score

The developed media can meet the effective criteria if the percentage of students completeness is higher than the specified standard or from previous learning. The complete development model flow can be seen in Figure 1.

3. Result and Discussion

3.1. Define

This study aims to produce certain products and test the effectiveness of these products. The product produced is ICT-based interactive multimedia for mathematical material that contains various forms of animation, learning material, games, and evaluation tests. Before conducting the research begins by analyzing the teaching needs, which begin by identifying the potential and problems in the field. From observations and interviews, it is known if SMK 1 Wonoasri uses the 2013 curriculum and is supported by a variety of facilities and infrastructure that support to conduct information technology-based learning such as computers, but not used optimally and in the learning still tends to use conventional teaching methods. The ability to solve mathematical problems is also still in the low category because students have difficulty working on non-routine problems. Based on this
identification, the main objective of this research is to develop ICT-based media to improve mathematical problem-solving skills.

3.2. Design
The results of the design phase are in the form of instructional media design as a result of the products developed, and test instruments which include media validation sheets, student response questionnaires, and evaluation test questions.

3.3. Develop
In this step, validation and testing were carried out using ICT-based media for students in the class.

3.3.1. Validity
The first instrument validated was the student response questionnaire sheet. The validation of the student response questionnaire was carried out by 2 validators as linguists and material experts. The validation results can be seen in Table 1 below.

| Table 1. Results of the validation of student response questionnaire sheets |
|----------------------------------|
| Validator | 1 | 2 |
| Total Empirical Score (Tse) | 208 | 247 |
| Total Expectation Score (Tsh) | 256 | 256 |
| Percentage (Vp) | 81.25% | 96.48% |
| Percentage of Final Validity (V) | 88.87% |

Based on the calculation of validation assessment in Table 1, was obtained a percentage of 88.87%, which means that the student response questionnaire was appropriate to be used to measure the practicality of learning media after several revisions were made based on suggestions and comments from the validator. Suggestions and comments from the validator including improvements to statement items that are more adjusted according to language that is easily understood by the students as research subjects and make more random statement items between positive and negative statements.

The second instrument is the evaluation test sheet. The validation results from the learning achievement test question sheets validated by the validator are presented in Table 2 below.

| Table 2. The results of the validation of the learning outcomes test sheet |
|----------------------------------|
| Validator | 1 | 2 | 3 |
| Total Empirical Score (Tse) | 63 | 79 | 75 |
| Total Expectation Score (Tsh) | 80 | 80 | 80 |
| Percentage (Vp) | 78.75% | 98.75% | 93.75% |
| Percentage of Final Validity (V) | 90.42% |

Based on the validation calculations in Table 2, the results of validation by three validators obtained an average percentage of 90.42%, so the test results are included in the learning criteria that are valid and feasible to measure the effectiveness of the media. Besides, there are suggestions and comments for improvement of the validator for the evaluation test sheet, including questions that must be more adapted to the conditions of students and also use language that is easily understood by students. Furthermore, revisions were made to correct the questions that were not appropriate and improve the quality of questions.

Next is the validation of the developed media design. The results of the validation of learning media are presented in Table 3 below.
Table 3. Animation Based Interactive Media Validation Results

| Validator | 1  | 2  | 3  |
|-----------|----|----|----|
| Total Empirical Score (Tse) | 166 | 175 | 171 |
| Total Expectation Score (Tsh) | 176 | 176 | 176 |
| Percentage (Vp) | 94.32% | 99.43% | 97.16% |
| Percentage of Final Validity (V) | 96.97% |

Based on the validation calculation of the three validators in Table 3 an average percentage of 96.97% was obtained, so the test results were included valid criteria for learning and were suitable for use. Also, there were suggestions and comments for improvement from the validator for media performance and need to be given instructions on how to operate the media. Then a revision was made to the media layout and operating instructions added.

3.3.2. Limited Product Trial

A limited trial was conducted on 6 students who were selected based on differences in cognitive abilities and subject teacher recommendations. The practicality of ICT-based interactive multimedia is known for filling in student response questionnaires. The results of filling in the student response questionnaire in the limited trial showed a figure of 76.04%, so it was concluded that the students' response to the learning media in the limited trial is positive which meant that interactive animation-based learning media met practical criteria.

ICT-based interactive multimedia is said to be effective if it meets the mastery of learning. Based on the results of the work on the evaluation test questions by students on a limited trial, the percentage of students' mastery learning was 81%, so it can be concluded that mathematics learning using ICT-based interactive multimedia meets classical completeness. Based on the results of the development of limited trials, it can be concluded that ICT-based interactive multimedia can be used in field trials because it meets the criteria of validity, practicality, and effectiveness.

3.3.3. Field Product Trial

In the field, trials were used 20 students selected based on differences in cognitive abilities and subject teacher recommendations. The results of the analysis of practicality of interactive multimedia based on ICT in field trials meet the practicality criteria because the positive percentage of respondents was more than 70%, amounting to 77.5%, so it can be concluded that students' responses to learning media in field trials are positive which means interactive learning media based animation meets practical criteria.

The effectiveness of ICT-based interactive multimedia seen based on the results of the work of evaluation test questions by students in the field trials obtained a percentage of students learning completeness by 84.45%, so it was concluded that mathematics learning using ICT-based interactive multimedia has met the classical completeness in field trials. Furthermore, after the product was tested, improvements were made based on data obtained from trials that had been carried out and carried out packaging as a product that was final and ready for use in learning. Developed ICT-based media was packaged in a CD and disseminated to teachers and schools.

Based on limited and field product trials, overall ICT-based learning media is categorized as "feasible" which means the media can be used in learning both in terms of material, media and users. This learning media is developed based on the potentials and problems that are explored directly from conditions in the field so that it can also increase the learning objectives to be achieved related to the improvement of better problem-solving skills. This media has a variety of interesting content and provides a new learning experience for students as well as increasing student interest in mathematics, in the form of images, animation, audio, and video. In terms of material, this media is organized based on various sources of reference that are made based on the desired needs and goals.
Besides, it also found advantages and disadvantages of this ICT-based media. The advantages are: First, it is developed based on the principles of multimedia-based learning that provide new experiences for students. Second, it was developed to improve students’ problem-solving abilities. Third, innovative and adapted to student’s characteristics. Fourth, appropriate for encouraging cognitive aspects in students based on the results of the material expert validation. The fifth, can increase student learning activities. The disadvantages are: First, media in the form of application files, so only can be run on a computer. Secondly, the product is only developed in one subject about the “chance” material in mathematics learning.

3.4. Disseminate
After the product tested and improved based on data obtained from trials and declared valid, practical, and effective, then the product is packaged as a final product and ready to be used in learning in the form of a learning CD. The next step is to make limited distribution of media and delivery to teachers and schools. It's hope that mathematics teachers who are members of the forum can use learning media for further lessons.

4. Conclusion
ICT-based interactive multimedia development research to improve problem-solving skills in the effort to deal with the industrial revolution 4.0 that had met the criteria of validity, practicality, and effectiveness with details: 1) The level of validity of the developed media meets the validity criteria with an average yield of 96.97%. The media developed are included in the criteria very well. 2) The practicality level of the developed media meets the practicality criteria with an average yield of 76.77%. 3) The effectiveness level of the developed media fulfills the effectiveness criteria with an average yield of 82.73%, with an average breakdown of the percentage of completeness of the results of student questions in a limited trial of 81% and an average percentage of completeness of the results in the test try the field at 84.45%. Thus ICT-based interactive multimedia to improve problem-solving abilities in the effort to deal with the industrial revolution 4.0 is feasible to use and recommended for application in mathematics learning.

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