The Development of Interactive Multimedia Based on Mathematics to Increase the Mathematical Connection Ability in Probability Learning

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Abstract. This research aimed to develop an interactive multimedia-based mathematics lesson using Adobe Flash on the probability material at SMK, to know the quality of media and increase student mathematical connection. This used the research development model 4-D. The instrument in this study is the learning media validation sheet, student’s response questionnaire to measure the media simplicity, and the question test to measure the media effectiveness. The results are described: 1) the validity level of mathematical interactive multimedia to improve the mathematical connection and the students' learning achievements meet the valid criteria with a result of 89.17%. 2) The practicality level of mathematical interactive multimedia to improve the mathematical connection and achievements of a student’s learning meet the practice criteria with results 83.71%. 3) the effectiveness level of the mathematical interactive multimedia to improve the student's mathematical connection meets the effectiveness criteria with results of 80.28%. The developed interactive mathematics multimedia can improve students' mathematical connection skills in probability learning of 27.62% on the first indicator and 36.18% on the second indicator. So, the interactive mathematics multimedia that was developed can improve student’s mathematical connection skills in probability learning at SMKN 1 Wonoasri.

1. Introduction
In the current era, reliable human resources must prepare in Science, Technology, Engineering, and Mathematics (STEM) discipline to deal with global competition, included in Indonesian [1]. Industrial revolution 4.0 forces every nation and country to innovate by taking advantage of the development of communication and information technology which is now transforming completely digital. Currently, digital technology has also been developed to be more usable in human work, and live [2]. There are many potential benefits for individuals and the nation as a whole [3].

One of the fields that must be at the forefront of preparing for an era of digital competition is education, included in mathematics learning. In the development of various sciences, there is a role of mathematics in it [4]. In learning, the teacher is an important factor that has a big influence on the success of the learning activities carried out. This is closely related to the models and media or teaching aids that will be used in mathematics learning. With the media, data could be possible in increasingly successful ways and tend to be attractive instructional tools for conveying learning material. Learning media has developed a variety of assets and equipment, which can be used to enhance or complement the instructor's efforts to ensure interesting learning by students [2].

One of the effective mathematics learning models used in Vocational High Schools (SMK) is an innovative and creative learning model. The learning aimed to build student's knowledge independently
in the process of changing student behavior for the better. This is because vocational education students aimed to prepare in the world of work and develop a professional attitude and prepare students to be able to work after graduating.

Based on the observations and interviews with teachers at SMKN 1 Wonoasri, Madiun Regency, it is known that students' mastery of mathematics is still low. The low mastery of this material is caused by several factors, including facilities and infrastructure, learning facilities, and the way the teacher delivers material that is not needed by students. The learning process used at SMK Negeri 1 Wonoasri is still dominated by conventional learning models, namely lectures and questions and answers. Although some teachers use computer-assisted learning media in the form of PowerPoints, the numbers are still limited. This results in very little interaction between the teachers and students during the teaching and learning in the class. The teacher realizes that without media, learning material is difficult for students to digest and understand, especially complex learning materials [5].

In education, especially in learning mathematics, the ability to connect a material with other material or with daily life plays an important role in the learning process. It is also conveyed by [6], that learning mathematics can help students in solving their problems in everyday life. Mathematics contains several abilities in which students must be able to master these abilities in learning, which is the ability to connect mathematically [7].

The mathematical connection is an important part that must be emphasized at every level of education. Mathematical relationships are links between math topics, linkages between mathematics or any other disciplines, and mathematical relationships with real life. The mathematical connection is an important part that must be given at each level of education [8].

The student mathematical connection skills need to be developed because it will help students understand a concept and can improve their understanding of other sciences by linking mathematical concepts with other concepts [9]. Mathematical connection skills are needed in mathematical learning because they have a good role in students learning [10]. Besides, mathematical connection skills need to be developed extensively because it can improve students' cognitive ability by remembering a concept, understanding, and applying the concept in daily life. Without it, students would feel challenged to learn mathematical concepts [11].

Strengthen mathematical connection learning strategies to make it easier for teachers to implement and do not require a long time, the presentation of the subject matter problems can be supported by examples of Information and Communication Technology (ICT) used Adobe Flash. Judged from its use Adobe Flash can help teachers design and develop instructional media in the form of animation that can be played with flash films.

The use of learning media based on ICT can improve the learning quality and also the education quality [7]. Today's integration of technology has gone through innovation and societal transformation that has changed how people think, work, and live [2]. Previous research has shown that STEM integration has a positive impact on the learning achievement of the elementary, middle, and high school students ([12],[13]). The development of modern technology required students to think logically, systematically, critically, creatively, and innovatively [10]. Implementation of ICT in learning is good to use because the media can increase achievement. So, integration of learning media based on ICT is positive in learning, so it is important for education practitioners to develop more ICT-based learning media that fulfil practical effectiveness, and valid criteria to help students understand mathematical concepts more effectively in learning [14].

2. Methods
This research is a type of Research and Development (RnD). This research aimed to make and develop new learning media in the form of interactive multimedia. The learning media developed was interactive multimedia-based learning media on probability materials to increase the mathematical connection ability of class XI Multimedia students of SMK Negeri 1 Wonoasri. Research and development methods could be defined as a scientific way of researching, designing, producing, and testing the validity of the
products that have been produced [15]. Meanwhile, according to [16] Research and development is a method for developing a new product or improving an existing product, which can be accounted for. This research used a 4-D model namely defines, designs, develops and disseminates. Activities in the defined phase analysis of potentials and problems are carried out, collected supporting data, and the formulating learning objectives. At the design phase the preparation of instruments test, selection of the media, and initial instructional media design. Activities at the development stage include design validation, design revision, limited testing, and field trials. Activities at the disseminate stage were used to develop interactive media that have been developed on a wide scale and product deployment.

3. Results and Discussion
The product developed in this study was interactive multimedia-based mathematics on the mathematics probability material for class XI SMK. This type of research is development research (RnD) by applying the 4-D model. The results of research that have been carried out by researchers are described as follows:

3.1. Define
The results of the define stage are described as follows:

3.1.1. Analysis of potentials and problems. Analysis of potential and problems is carried out by observation and interviews. From the observations made, several data were obtained by researchers, included the number of expertise/department programs in this school, which were 8 expertise programs, while the curriculum used at SMK Negeri 1 Wonoasri was the 2013 curriculum, with teaching methods carried out by teachers in the form of lecture methods, question and answer, and discussion.

Apart from these direct observations, also conducted interviews with the subject teachers of mathematics at SMK Negeri 1 Wonoasri. From the observation and interview activities, there were some obstacles in the learning process at SMK Negeri 1 Wonoasri, especially in mathematics, included: 1) Student interest in mathematics was still low, 2) The uses of interactive media in the learning process are still very few teachers, the majority use the lecture & discussion method, 3) There are not interactive mathematics learning media to increase mathematical connection ability in learning.

3.1.2. Collecting data. After analyzing the potential and problems, the next step is to collect the observed data from the analysis activities that have been carried out previously. The data obtained is used as a source in designing the product to be developed. From the data collection carried out, the following data were obtained: 1) The material chosen was mathematical probability material, 2) The research was conducted at SMK Negeri 1 Wonoasri, 3) The product developed was based on the existing potential in SMK Negeri 1 Wonoasri and had never been used before, 4) The product developed must be able to be used as suitable and interactive multimedia learning for SMKN 1 Wonoasri students.

3.1.3. Formulation of learning objectives. After observation and analysis of potential problems that are supported by collecting data that support these potentials and problems, the researcher must then formulate the learning objectives to be carried out. In this case, the researcher aims to increase student independence, which is observed from the independence observation sheet and measured from learning achievement in the cognitive aspect. So that the media design to be developed must aim to increase the mathematical connection ability of students.

3.2. Design
The second stage in this research is design, the results of the design activities can be described as follows:

3.2.1. Preparation of test instruments. The test instruments used for interactive multimedia-based mathematics learning media include media validation sheets, questionnaires response of students, and student learning outcomes tests. The learning outcomes test questions are arranged in the form of an essay, consisting of 6 items, which contain mathematical probability material. The test instrument
that has been compiled by the researcher is tested for validity on the expert/validator before being tested directly on students in limited trials and field trials.

3.2.2. Media selection. This research develops an interactive multimedia-based learning media. Media is developed using Adobe flash because through Adobe flash the material can be packaged more attractively and interactively to increase student interest in learning. This interactive media can be used in mathematics class, especially in mathematics probability material for class XI Vocational High Schools, and makes students more interested in learning mathematics because it is packaged attractively and there are examples of questions based on the context of daily life which are packaged interactively and there are also games. That can be used to measure students' abilities of probability material in a fun way. Besides, in these media researchers also develop instructional media in such a way that the media can be used to improve student connection ability in mathematical learning.

3.2.3. Initial design of learning media. The material that was developed in this media is the probability of mathematics at XI class SMK. The selection of the material because the material of mathematics was considered quite difficult for students, this was supported by the low student’s scores in mathematics and also supported by the results of discussions with the mathematics teaching teacher of SMK Negeri 1 Wonoasri. So, it is necessary to have an attractive learning media to build student interest in mathematics, especially for mathematics probability material. This media is also equipped with games as well as evaluation questions and enrichment questions for student practice. The media is designed in such a way that the media can be used as an interactive and fun in learning, and can increase students' mathematical connection ability.

3.3. Develop
The next phase is the development, the activities in the development stage are described as follows:

3.3.1. Expert validation. The test instruments and the initial learning media design that the researcher has been developed must be submitted to be validated by the validator.

3.3.2. Instrument validation. In the validity test of the instrument student learning outcomes on the probability material used 3 validators to validate the test instruments prepared by the researcher. The validators of this interactive multimedia-based mathematics learning media test instrument were two lecturers of Mathematics Education at PGRI Madiun University and a mathematics teacher from X grade at SMK Negeri 1 Wonoasri. The validation results of the student learning outcomes by the validator can show in Table 1.

| Validator | Total Empiric Score | Total Expectations Score | Percentage | Percentage Final Validity |
|-----------|---------------------|--------------------------|------------|--------------------------|
| 1         | 72                  | 96                       | 75%        | 84.03%                   |
| 2         | 79                  | 96                       | 82.29%     |                          |
| 3         | 91                  | 96                       | 94.79%     |                          |

3.3.3. Media Validation. The product design of the product developed by the researcher is submitted to the media validator for validation. The media validators appointed in this development research consisted of 4 experts as experts, namely: Lecturers of the Mathematics Education &Microteaching Laboratory Assistant at the University of PGRI Madiun, mathematics teachers & multimedia teachers of XI class SMK Negeri 1 Wonoasri.

The validation results of interactive multimedia-based mathematics learning media that have been assessed by the validators according to the validity criteria can show in Table 2.
Based on the results of the validation in Table 2 above shows that the learning media was developed and got a final validity percentage of 89.17%. The formula for data validation is stated as follows [17]:

\[ V = \frac{Total \ Empirical \ Score}{Total \ Expectancy \ Score} \times 100\% \]

So that learning media can be used directly for limited trials and field trials.

3.3.4. Design Revision. Design revision is made based on the suggestions given by the validator during validation. From the results of the validation and also the improvements that have been made, the final appearance of the learning media used to test the eleventh-grade students of SMK Negeri 1 Wonoasri in limited trials and field trials were obtained.

3.3.5. Limited trial. The limited trial involved six students from XI class Multimedia 1 SMK Negeri 1 Wonoasri which is selected through the cognitive abilities, consisting of two high cognitive ability students, two medium cognitive abilities, and two low cognitive abilities.

The practicality analysis of the interactive multimedia-based mathematics learning was obtained from the results of filling out a questionnaire as a response from students after using interactive multimedia-based mathematics learning media. Analysis of the practicality of interactive multimedia-based mathematics learning on limited trials was obtained from the results of filling out a questionnaire by XI class MM 1 students of SMK Negeri 1 Wonoasri. The results of filling out the student response questionnaire by six students from XI class MM 1 of SMK Negeri 1 Wonoasri on the limited trial can show in Table 3.

| Number of scores obtained | Total criterion score | Percentage of practicality |
|---------------------------|-----------------------|-----------------------------|
| 295                       | 336                   | 87.80%                      |

It can be seen in Table 3 above that the percentage of student responses in limited trials shows 87.80%. The effectiveness of interactive multimedia-based mathematics learning media is determined by the students' mastery score after taking the learning outcome test. The learning outcome test is done by students after learning to use interactive multimedia-based mathematics learning media. The result of learning completeness in the limited trial can show in Table 4.

| Number of scores obtained (T) | 471 |
|------------------------------|-----|
| Total Score (Tt)             | 600 |
| Percentage of learning completeness (KB) | 78.5% |
The results of learning completeness that shown in table 4 can conclude that the interactive multimedia-based mathematics learning media has met limited completeness with completeness attainment of 78.5%.

3.3.6. Field trial. Field trials were conducted in XI class MM SMK Negeri 1 Wonoasri with a total of 21 students. In this activity, the learning used interactive multimedia-based mathematics learning media with probability material. After that, work on practice questions and games in the media and fill out a questionnaire. Then proceed with doing the learning outcome test questions.

The results of filling out the student response questionnaire by 21 students of XI class MM 2 SMK Negeri 1 Wonoasri in the field trial can show in Table 5:

| Number of scores obtained | The total score of the criteria | Percentage of practicality |
|---------------------------|-------------------------------|---------------------------|
| 1624                      | 2040                          | 79.61%                    |

It can be seen in Table 5 above that the percentage of student responses in field trials shows the number 79.61%. The effectiveness of interactive multimedia-based learning media is determined by the value of student completeness after taking the learning outcome test. The learning outcome test is done by students after learning to use interactive multimedia-based mathematics learning. The result of completeness in the limited trial can show in Table 6.

| Total Empirical Score | Total Expectation Score | Percentage |
|-----------------------|-------------------------|------------|
| 2756                  | 3400                    | 81.06%     |

Based on the results of learning completeness in Table 6. It can be concluded the interactive multimedia-based mathematics learning media has met classical completeness with completeness achievement of 81.06%.

3.3.7. Analysis of mathematical connection skills of students. Learning using interactive multimedia-based learning media can increase student mathematical connection skills. based on the results from the mathematical connection test. The results of the mathematical connection ability test before students use the media on the indicator of the relationship between mathematics and daily life is 54.28%. While the results of the mathematical connection ability test after students use the media are 81.90%. Then the mathematical connection ability test results before students use the media to indicate the relationship between objects with mathematical concepts is 19.05%. %. While the results of the mathematical connection ability test after the students use the media are 55.23%. So it can be concluded that interactive multimedia-based mathematics learning media can improve a student's mathematical connection ability. The details of mathematics connection ability before use media can be seen in Table 7, and the calculation of the improved mathematical connection abilities can be seen in Table 8.

Table 7. Percentage of mathematical connection abilities (pre-task)

| Indicators                                          | Score | Total Score | Percentage | Category |
|-----------------------------------------------------|-------|-------------|------------|----------|
| The relationship between mathematics and daily life  | 57    | 105         | 54.28%     | LESS     |
| The relationship between objects with mathematical  | 20    | 105         | 19.05%     | VERY LESS|
| concepts                                             |       |             |            |          |
Table 8. Percentage of mathematical connection capabilities (post-test)

| Indicators                                           | Score | Total Score | Percentage | Category      |
|------------------------------------------------------|-------|-------------|------------|---------------|
| The relationship between mathematics and daily life  | 86    | 105         | 81.90%     | WELL          |
| The relationship between objects with mathematical   | 58    | 105         | 55.23%     | GOOD ENOUGH   |
| concepts                                             |       |             |            |               |

3.4 Disseminate.
In this disseminate stage, the interactive multimedia that was developed disseminated for used at wide-scale mathematics learning and published at an education conference.

4. Conclusion
From the development of the result of interactive multimedia-based mathematics learning media that have been carried out, the following results were obtained: (1) The validity level of mathematical interactive multimedia to improve the mathematical connection and the students learning achievements meet the valid criteria with a result of 89.17%. (2) The practicality level of mathematical interactive multimedia to improve the mathematical connection and learning achievements of students meet the practice criteria with results 83.71%. (3) The effectiveness level of the mathematical interactive multimedia to improve the mathematical connection of students meet the effectiveness criteria with results 82.55%. The development of mathematics interactive multimedia can improve the mathematical connection of students. The developed interactive mathematics multimedia can improve students’ mathematical connection skills in probability learning of 27.62% on the first indicator and 36.18% on the second indicator. So, the interactive mathematics multimedia that developed is worthy to use in learning to improve the student’s mathematical connection ability.

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