Development of circle learning media to improve student learning outcomes

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Abstract. The purpose of this research was to develop mathematics learning media which were valid, practical, and effective. The mathematics learning media which was developed in this study consisted of mathematics instructional media which the topics was circle. Data were collected by using observation sheet of instructional media implementation, student’s and teacher’s response questionnaire, and test of students learning outcomes. The collected data analyzed descriptively. The result of this research showed that the mathematics instructional media were categorized very high in validity, had fulfilled the practicality and the effectiveness aspects. The characteristics of the instructional media are: (1) practical usage; (2) learning activities were guided students to think critically and creatively; (3) exercises and real problems gave students the opportunity to think about alternative solutions to solve problems; and (4) provide variations in the learning.

1. Introduction
Mathematics develops the mind to think critically and analytically. It is more than counting, measuring, and computing. It is an eye opener to all sciences. As far as Mathematics instruction is concerned, the major goal is the involvement of the students in the process of discovering mathematical ideas and formulating process. One of the interesting concerns about learning Mathematics is the fact that it develops the mind to solve problems that need higher order thinking skills. These problems and puzzles induced the curiosity and challenge the ingenuity of individuals. Introducing problem solving into the classroom improves students’ skills and their ability to think creatively, logically and carefully. Solving math problems as an important aspect, and becoming a necessity in a mathematics curriculum throughout the world [1].

Students can understand mathematics if they are active in developing their knowledge. Besides, mathematical teaching should make sense, the students should be taught to be able to understand the use of mathematics correctly [2]. Teachers may use appropriate manipulative objects to bring math to life and to make the invisible math concepts visible [3]. In mathematics learning, there are various types of strategies that are carried out to improve the success of the learning process in the classroom. Problem solving ability is one indicator that determines the success of classroom learning. Hutkemri and Zakaria describe that teaching strategies and techniques are vital in the transfer of new information into the memory in a form that is easily understood. The quality of teaching can be measured by the number of the students who can understand the concepts taught. Successful and effective instruction emphasizes the learning of strategies that enable the students to learn with understanding [4]. One strategy that can have a positive influence on students' problem solving abilities is REACT learning strategies. The REACT learning strategy is a learning strategy consisting of five stages, REACT (relating, experiencing,
applying, cooperating, and transferring) [5]. This strategy has five activities that can be carried out by students, namely relating, experiencing, applying, cooperating, and transferring. REACT strategies will be accommodated in the developed media. Based on the stages of the learning stages contained in the REACT learning strategy, of course, each stage has a very positive effect on students’ problem solving abilities.

Apart from the aspect of the learning strategy, which is very influential on the ability to solve problems is the problem itself. Realistic problems are problems that are associated with the real world that students are accustomed to or problems that involve the situation so that students can imagine concretely the problem in their minds. The realistic mathematics education approach addresses this problem by encouraging mathematics to be more relevant and appealing to learner needs [6]. RME makes learning mathematics meaningful and enjoyable to learners. Once learning is meaningful and enjoyable to learners, the sky is the limit for their successes. Directly when students try to understand information from a given realistic problem, unconsciously establish connections in the brain to process the links between mathematical concepts that students already know. According Rahayu, when students learn Math is separate from their daily experience it will easily to forget and can’t apply mathematics. Based on the above opinion, mathematics learning in the class is emphasized on the interrelation between mathematical concepts with the experience of everyday children [7].

Based on the realistic mathematical problems in learning mathematics have an important role so children can see the benefits of mathematics in real life and in other fields and develop student reasoning and can be used as a source of inspiration for the formation and construction of mathematical concepts or the development of concepts mathematics. But in the reality in the classroom when students are given words math problems, students tend to have difficulty solving it. This is because the initial thinking of students who always think of math problems is very difficult and sometimes students are easy to give up and do not want to try to solve it. Therefore, to motivate students to be more interested in the problems that are given mathematical problems, the words problems given are as realistic as possible and can be imagined by students. Because if students have been able to imagine about these problems, then there will be curiosity to find solutions to the problems. Therefore, the learning provided must provide wider opportunities for students to process information analyze and search for solutions themselves from the information that has been collected. Seeing the importance of the role of realistic problems in learning, the application of REACT learning strategies is accompanied by realistic problems to students in order to improve problem solving skills. The relationship between REACT strategy, problem solving skills and developed media can be seen in Figure 1.

![Figure 1. Relationship between REACT strategy, problem solving skill and media](image-url)
2. Methods

This research is a design research whose theory refers to the development research by Plomp. Based on this theory, there are three phases in design research, which include: preliminary research, prototyping, and assessment [8]. The purpose of this research is to develop a product, namely learning circle media for class XI. The media designed in this study uses GeoGebra software that is oriented towards REACT strategy. In addition to the media, this study will also prepare supporting learning tools in the form of Learning Implementation Plans (RPP) that are appropriate to the topics in the media. Learning media that is designed to be determined by quality are based on three aspects, namely validity, practicality and effectiveness.

Students play a role in obtaining data about practicality and effectiveness of learning devices in the form of learning media. The students in question are students of class XI SMA Negeri 1 Kuta Utara especially class XI IPA 1, XI IPA 2, and XI IPA 5. Selection of class XI as the subject of research is based on several considerations which basically support the realization of developed learning tools namely characteristics heterogeneous students, equal class ability, and apply the 2013 curriculum. In addition, the selection of research subjects is because students who have not constructed a concept by using mathematics learning media but only use LKS that has been provided by the publisher. The teacher plays a role in obtaining data about the practicality of the whole learning media. The teacher referred to here is a mathematics teacher in class XI SMA Negeri 1 Kuta Utara.

In the preliminary research phase, it is focused on analyzing the situation, needs and problems that occur in learning mathematics in schools. The activities carried out in this phase are; 1) carry out observations on the learning process, 2) carry out interviews to class XI math teachers and some class XI students, 3) carry out document analysis namely documents concerning the mathematics learning outcomes of class XI students and review media and learning tools used in mathematics learning in the classroom. In addition to conducting field studies, in this phase literature studies were also conducted and reviewing examples of relevant mathematics learning media for consideration in making media. From the results of identification of the implementation of learning and media and supporting tools for mathematics learning, further studies were found to be used to design the media and its supporting devices in the form of RPP. In addition, an initial draft of the media that was oriented towards the REACT strategy was also drafted. This initial draft is called prototype I.

In the prototyping stage development of a sequence of prototypes that will be tried out and revised on the basis of formative evaluations. Early prototypes can be just paper-based for which the formative evaluation takes place via expert judgments. The validity of the learning media was judged by two validators. Based on the results of this validation test then it was revised so that it obtained valid quality prototype II learning tools for try out. The try out were conducted to determine the practicality and effectiveness of the developed learning media. The first try out conducted was a limited try out. In a limited try out, the media was tested on 12 students of class XI IPA 1. The focus of this implementation was to get an overview of the implementation of mathematics learning using learning media. Suggestions obtained at this stage were used as material for revision of prototype II so that prototype III was formed.

Then the prototype III which was compiled was then tested. This implementation was then called the 1st try out which was carried out in one class, namely class XI IPA 2. The focus of this try out was to improve product quality or get characteristics of learning media developed that were practical and effective. In addition, students are also given a problem solving ability test. The results of giving questionnaires and tests were used as consideration to revise prototype III. The results of prototype III revision are called prototype IV. In the assessment phase carried out 2nd try out involving students of class XI IPA 5. The response results of students and teachers are used as revisions, so that the characteristics of learning media that are practical and effective (final products) are obtained. The data that has been collected is then processed descriptively. Learning tools in this study must at least reach a valid, practical and effective category.
The learning tools developed will be determined based on the criteria as shown in Table 1 below. Valid categories are given if the average score of the two validators is at least in the range $2.5 \leq V < 3.5$ and the validation of the problem solving test is at least 0.7.

| Score       | Criteria   |
|-------------|------------|
| $3.5 \leq V_r \leq 4.0$ | Very valid |
| $2.5 \leq V_r < 3.5$   | Valid      |
| $1.5 \leq V_r < 2.5$   | Invalid    |
| $1.00 \leq V_r < 1.5$  | Very invalid |

Learning tools in this study must at least reach a high category of being in the range of scores $2.5 \leq Pr < 3.5$ to be declared practical and can be used in classroom learning. Criteria for the level of practicality of the learning tools developed are in accordance with Table 2 below.

| Score       | Criteria   |
|-------------|------------|
| $3.5 \leq V_r \leq 4.0$ | Very practical |
| $2.5 \leq V_r < 3.5$   | Practical  |
| $1.5 \leq V_r < 2.5$   | Quite practical |
| $1.00 \leq V_r < 1.5$  | Very impractical |

Data regarding students' mathematical problem solving abilities can be obtained through tests of mathematical problem solving skills performed in the final stages of the implementation/try out. The test was given in the form of essay problem because in answering the description questions students are required to be able to develop their knowledge and skills. However, the essay problem has weaknesses in examining answers that tend to be subjective. To anticipate this, in scoring students' answers, a scoring rubric was made.

Mathematical problem solving tests are examined using the analytic scoring rubric, meaning the scoring rubric used is adjusted to the problems given in the test. This is considering the level of difficulty, and the variation of each problem varies so that the rubric used also varies. While the criteria for classifying students' problem solving abilities are adjusted to Table 3 below.

| Score       | Categories |
|-------------|------------|
| $\bar{X} \geq 80$ | Very high |
| $60 \leq \bar{X} < 80$ | High |
| $40 \leq \bar{X} < 60$ | Quite high |

### 3. Results and Discussion

Learning tools developed in this research are learning media. The resulting product is different from the learning media used so far in school. The difference is that the use of developed media not only requires students to "watch" but also helps students to rediscover a circle concept. This is also supported by the use of Geogebra-based learning media. Based on the results of the design research that has been carried out, the product development procedure in the form of REACT learning media is in principle the same as the development procedure according to Plomp.
In the preliminary research phase, it was found that 1) students did not understand how to construct a circle equation properly, 2) students still had difficulty in reconstucting a concept, 3) students were only able to solve routine questions given by the teacher, 4) problem solving ability of students is still low, and 5) students have never learned to use the media. From the results of the identification, the media and research instruments were then designed. In the prototyping stage the learning tools that have been compiled are seen in their quality. The things that were done are to test the media validity that is still in the form of prototype I by two validators. Not only assessing the validity of the media, the validator also assesses the validity of the instrument that will be used in the trial activities.

Based on the results of the validation test on the media, then it was revised so that the learning media obtained in prototype II form were obtained with the criteria of the learning device developed was valid. Likewise, instruments to measure practicality and effectiveness such as student and teacher response questionnaires, observation sheets, and problem solving tests are categorized as very valid. After the learning tools were obtained in prototype II form, then try out was conducted to determine the applicability, practicality, and effectiveness of the learning media. The result of practicality and effectiveness of learning media that was conducted in limited try out, 1\textsuperscript{st} try out and 2\textsuperscript{nd} try out were shown on the Table 4 below.

| Prototyping Phase | Scores of Practicality Criteria | Scores of Effectiveness Criteria |
|-------------------|---------------------------------|---------------------------------|
|                   | Student’s responses              | Teacher’s responses             | Problem solving test | Practical | Very high |
| Limited try out   | 3.12                             | 2.94                            | Practical            | 82.13      | Very high |
| 1\textsuperscript{st} try out | 3.06                             | 3.34                            | Practical            | 81.17      | Very high |
| 2\textsuperscript{nd} try out | 3.28                             | 3.46                            | Practical            | 82.13      | Very high |

With an increase in the average problem solving score equal to or more than the KKM, the media developed can be said to be effective. So, generally in prototyping phase the learning media have met the criteria for valid, practical, and effective. Based on the try out activities and studies of supporting theories it can be concluded that there are several things that cause the developed media to meet the criteria of valid, practical and effective.

The media developed can be classified as valid because a) the media developed are in accordance with the demands of the curriculum, the meaning is the characteristics of the curriculum to be one of the guidelines in preparing media that aims to achieve what is expected in the curriculum when learning uses activity sheets, b) media can motivate students in learning due to activity sheets developed in accordance with the level of development of students, c) focused learning activities on students that make it easier for students to rediscover a concept by using Geogebra's help. The use of learning media, such as Geogebra, in addition to help students grasp experimental, problem-oriented and research-oriented learning of Mathematics, both in the classroom and at home [9].

Furthermore, the media developed is relatively practical because it provides benefits to teachers and students. Some of the benefits provided are a) the media used can foster students' enthusiasm in learning geometry, especially circles because students are given steps in rediscovering a concept, b) media can facilitate students to make conclusions, c) focused learning activities on students that make it easier for students to rediscover a concept by using Geogebra's help. The use of learning media, such as Geogebra, in addition to help students grasp experimental, problem-oriented and research-oriented learning of Mathematics, both in the classroom and at home [9].

The findings of this study are consistent with the study by Ilhan which found a positive impact of utilizing mathematical learning software and thus enhancing students learning and understanding [10]. It demonstrates the instructional effectiveness of GeoGebra and REACT strategy compared to the
traditional construction tools. Alternative to the teachers to utilize the integrating of learning strategy and mathematics software as a tool in their instructional activities.

In addition, statistically the average value of students who are taught with REACT learning strategies is assisted by realistic problems classified as high categories. This shows that students' mathematical problem solving skills that are taught by REACT learning strategies assisted by realistic mathematical problems show better results. These results are equivalent to the results of research by Lingefjärd showed that students perceived DGE explorations as less time consuming, more accurate and easier to attempt as compared to paper and pencil tasks [11]. They also used external representations aside of GeoGebra, such as verbal explanations, drawings, and notes on paper-and-pencil. In addition experiments conducted by Özbay, Ali & Kayaoğlu, Mustafa showed increased students motivation to a higher level and helped them use and retain the knowledge far more than the traditional classroom teaching methods [12].

4. Conclusion
Based on the results of the research and discussion as mentioned above, it can be concluded that the learning media has fulfilled the criteria of validity, practicality, and effectiveness that are expected and are able to improve students' problem solving abilities. The characteristics or features of the learning tools developed in this study include the following: 1) practical use; (2) learning activities lead students to get used to solving mathematical problems; (3) practice questions and real problems that provide opportunities for students to think of various alternative solutions to problem solving; and (4) provide variation in learning.

For further researchers who want to develop innovative mathematics learning can make the results of this study as a guideline both in terms of development procedures and processes to see the quality of learning devices. It should be noted, that the results of this study still need to be followed up in the form of socialization of this learning media to teachers in high school so that the developed learning tools can be accepted and used in classroom learning activities.

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