Development of constructivism-based mathematics learning tools for eleventh graders

F Hidayati¹, I M Arnawa¹, S Bahri²

¹Department of Mathematics Educations, Universitas Negeri Padang, Indonesia
²Department of Mathematics, Universitas Andalas, Padang, Indonesia

*Corresponding email: hidayatifithri@yahoo.co.id

Abstract. Critical thinking skills are complex thinking abilities, so they can determine what students must believe and do. An attempt to improve the critical thinking skill is by applying the constructivist approach to the learning tools. The learning device was tested on students’ class XI of SMA N 2 Lubuk Basung. This research is development research that implements Plomp design. There are three stages that should be done. The first stage is the initial investigation stage (preliminary research). Next is the development stage (development or prototyping stage). Last is the assessment stage. This research is only limited to one to one stage because it is in the COVID-19 period. Three eleventh graders of SMA N 2 Lubuk Basung become the subject of this research. There are three instruments used in this study: validation sheets, student questionnaire responses, and interview sheets with teachers and students. If the learning tools satisfy content and construct validities, they are considered valid. The results of the validation of the RPP and LKPD experts were 0.95 and 0.96 with a valid category. The conclusion based on the research finding is that the constructivism-based mathematics learning tools for eleventh graders of SMA N 2 Lubuk Basung can be declared valid.

1. Introduction

Most students in all levels of education think that mathematics is a difficult subject [1-12]. It is because it requires the students to have high critical thinking ability [13]. It seems to be a difficult subject because the school encourages the students to come up with correct answers rather than assuring them to think of new ideas or rethink existing conclusions [13]. This is in line with what Jacqueline and Brook believe [14]. They explain that a few schools teach their students' critical thinking. The result of class observations by the researchers finds out that the teachers teach rather quickly. In addition, in the learning process, the teacher is more dominant when explaining the concept to the students. The teacher continues to provide the application of the concept in the form of sample questions and followed by exercises. Activities done by the students are only listening and taking notes. They rarely initiate to ask questions, discuss, or learn independently.

According to the problem that is explained above, an improvement in mathematics learning is required. It is particularly to train the students to think more critically. Therefore, the learning objectives can be met, and the students will no more find difficulty in working on non-routine problems. Non-optimal learning is inseparable from the developed learning resources. The learning resources used in the class are LKPD (student worksheet) and RPP (lesson plan).

LKPD and RPP in this study are constructivism-based. Constructivism is a learning process that actively involves the students, applies independent learning skills, develops self-knowledge, whereas the teachers are only to act as facilitators and mediators. It is not a new approach in the education
world. However, recently, this approach takes larger attention due to many supports from various research findings. According to this approach, learning is a process of understanding new information. It is in the form of continuous knowledge compilation through the interpretation of concrete experiences and based on prior knowledge. The constructivism approach is emphasizes the importance of students building their knowledge through active involvement in process of learning [15]. On most occasions, the learning process is based on the students' activities. In the theory of learning, constructivism allows the students to promote new notions and insight based on their prior knowledge [16]. It focuses on preparing the students to solve problems, working in groups, and exchanging ideas [17]. As a result, the students who learn actively are not those who receive lessons passively.

There are five elements of constructivism [18] are as follows: (1) Orientation. It is a moment to boost the students' motivation to learn a new topic. The students can observe what they are going to learn; (2) Elicitation. At this point, the students can speak up their minds through some activities, such as discussion, writing, making posters, and etcetera. They have a chance to talk about their observation in various forms, such as posters, pictures, and pieces of writing; (3) Idea restructuring. It consists of three points: (a) Clarification. It is a discussion on different ideas among students; (b) Building new ideas. This happens when the ideas conflict with other ideas or the idea cannot answer the questions raised by friends; (c) Evaluate new ideas with experiments. If possible, it would be good if the newly formed idea is tested with a new experiment or problem; (4) Idea usage in different conditions. Ideas or knowledge that have been formed by students need to be applied to a variety of situations encountered. This will make students' knowledge more complete and even more detailed with all kinds of exceptions; (5) Review. It is when the idea changes. The idea can change when implemented in everyday life. The idea revision is done by adding statements to make it more detailed.

Thus, learning mathematics using the constructivist approach and the traditional approach is quite different. In constructivism, the role of a teacher is not the provider of the final answer to students' questions but rather directs them to form mathematical knowledge so that a mathematical structure is obtained. Whereas in the traditional approach, the teacher dominates learning and the teacher always answers 'immediately' to student questions.

RPP and LKPD involve the constructivist approach because it can boost the students' critical thinking skills. RPP is a lesson plan used in direct learning activities. It can be used in one or more meetings. RPP refers to the syllabus, textbooks, and teacher's manual to guide the students to achieve KD (basic competence) [19]. Complete and systematic RPP should be prepared by every teacher. Therefore, they can create a fun atmosphere in the class and initiate the students to take part in the lesson. An opportunity to make the students more creative, independent, and interested both physically and psychologically is also important.

RPP is assisted by LKPD in the learning process. LKPD is useful to help the students achieve learning objectives. LKPD is a guide that is used to carry out the investigation or problem-solving activities. It can be in the form of a guide to improve the cognitive aspects of training or a guide to improve aspects of learning in the form of experiments or demonstrations [20].

A teacher who chooses to use LKPD in learning, especially those who compile themselves, needs to pay attention to many things. The selection of LKPD must be in accordance with the functions and objectives of the preparation and making of LKPD. The function of preparation and use of LKPD in general learning is as a teaching material that can decrease the teachers' role but more activating the students. LKPS should make it easier for the students to understand the material. It is a concise and rich teaching material for practice so that it makes it easier in the implementation of teaching to students [21].

2. Materials and Methods
This study is developmental research that applies Plomp design. There are three steps to conducting this research. First, it is called preliminary research. The second stage is the development or prototyping stage. The last step is the assessment phase. There are four analyses implemented in the first stage. They are needs, curriculum, concept, and student analyses.
Need analysis is used to obtain more information about the issues appearing in the existing teaching and learning activities as well as the mathematics learning tools. There are some ways to obtain the information, such as an interview with teachers and observation of the implementation of the questionnaire learning for eleventh graders of SMA Negeri 2 Lubuk Basung. Meanwhile, the curriculum analysis analyzes the curriculum implemented in mathematics subject for eleventh graders of SMA Negeri 2 Lubuk Basung. This analysis is useful to obtain information about the scope of materials, objective of learning, and appropriate approach underlying the expected learning tool development.

The concept analysis is done to describe, specify, and organize the main materials that will be given to the students. This analysis aims to identify the required content and materials and in accordance with the mathematics learning tools. In addition, the desired characteristic, learning method, and LKPD are analyzed in the student analysis. It is done by distributing a questionnaire to students.

At the development or prototyping phase, the researcher begins to draw a design for developing constructivism-based mathematics learning tools which include RPP and LKPD. At this stage, several stages are carried out, namely Self-Evaluation, where the researcher evaluates the product that has been designed for himself. The aim is to check for possible errors that still exist in the developed learning tools.

Expert review is a process of assessment and consultation with the relevant experts to get an insight into the prototypes that have been designed. Those who are relevant to give review include experts in mathematics education, Indonesian, and learning design. They are asked to fill in the validation sheets and discuss valid and feasible constructivist-based learning tools.

The next step is the One-to-One evaluation, which is carried out by asking product users for advice on evaluating the product. The evaluation is conducted on the learning tools that have been deemed valid by the experts. The evaluation aims to determine errors, including bad comprehension of grammar, confusing instruction, usability, attractiveness, and satisfaction. The instrument for the evaluation is the interview guide.

3. Results and Discussion
In the preliminary research phase, namely on the results of the needs analysis, the information was obtained from the interview done with the mathematics teacher as well as the observation of implementation of the learning questionnaire for the eleventh graders of SMA Negeri 2 Lubuk Basung. The interview result is as follows:

| Question                                      | Answer                                                                 |
|-----------------------------------------------|------------------------------------------------------------------------|
| Is the LKPD used suitable for facilitating students? | There is no LKPD used yet. I hope that the LKPD used can facilitate students in learning mathematics. |
| What about the learning outcomes of students in the class? Satisfactory or unsatisfactory? | Learning outcomes obtained by students have not been satisfactory. |
| Is the implementation of learning in accordance with the developed lesson plans? | Not yet |
| In my opinion, LKPD is good for students to use, such as? | LKPD that can arouse student learning motivation |
| Is the LKPD used suitable for facilitating students? | I have not used LKPD |
| What percentage of students who like math? | It is estimated that only 40% |
| What is the reason underlying students do not like math? | Because many students think that math is difficult |
| What sort of activities are often done by students who do not like mathematics in the learning process? | Most of the students are chatting with my classmates. |
| What are the teacher's tips for students to like mathematics? | Interesting learning |
The researcher also distributed questionnaires to 29 students about the characteristics of LKPD. The results of the questionnaire obtained the conclusion that the desired LKPD is to have an attractive and colorful appearance, easy to understand, have attractive pictures and illustrations of images that are appropriate and help to understand the material, LKPD size according to size in general, namely using A4 paper.

When doing the curriculum analysis, a review of the 2013 curriculum for Mathematics class XI Semester II was found as follows:

| Observed aspects | Yes | Not yet | No | Note |
|------------------|-----|---------|----|------|
| The suitability of KI and KD in the 2013 curriculum | √   |         |    |      |
| KD compatibility with learning indicators | √   |         |    |      |
| Indicator conformity with learning objectives | √   |         |    |      |
| Learning suitability with student characteristics | √   |         |    |      |

The concept analysis was done to obtain facts, fundamentals, notions, and measures that should be comprehended by the students. Furthermore, the analysis result became the benchmark to develop the Constructivism-based learning tool.

| Observed aspects | Yes | Not yet | No | Note |
|------------------|-----|---------|----|------|
| Problems related to current teaching material | √   |         |    |      |
| Material that is difficult for students to understand | √   |         |    |      |
| Material that bores students | √   |         |    |      |
| Material that is not known to be used by students | √   |         |    |      |

The students' characteristics were identified through student analysis. Therefore, the resulting device was relevant to the students' characteristics. The information was obtained by giving questionnaires to the students. For the purposes of this study, the researcher took samples in class XI in SMA Negeri 2 Lubuk Basung. Data obtained from this stage are:

| Observed aspects | Yes | Not yet | No | Note |
|------------------|-----|---------|----|------|
| Characteristics of students in accordance with the learning device developed. | √   |         |    |      |
| Students are motivated by the assessment conducted. | √   |         |    |      |
| Students like the method used by the teacher | √   |         |    |      |

According to the four analyses, RPP and LKPD as the learning tools were designed based on constructivism. RPP (lesson plans) was arranged systematically. The component of RPP was according to Permendikbud No. 22 of 2016. It became the teacher's guidance to convey the learning materials to the students.

The designed and developed LKPD referred to the characteristics of the constructivism approach. LKPD was designed to help students to construct, discover for themselves new knowledge related to learning material based on indicators of competency achievement. LKPD size was adjusted to LKPD size commonly used by students, namely A4 HVS size. LKPD presentation consisted of: (1) Cover; (2) Instructions for using LKPD; (3) Core Competencies and Basic Competencies; (4) Meeting number on LKPD; (5) Title of Material; (6) Aspect of content presentation. There are steps from the constructivism approach in the form of orientation, elicitation, idea restructuring, use of ideas, and review.
The results of the design of learning devices at an early stage were called prototype I. Prototype 1 was a revision of the self-evaluation of the learning device that has been developed. Self-evaluation was called an evaluation conducted on a device that was done by himself. Activities carried out by looking back at the results of the design of the device and correct errors that were clearly visible on the device. These errors can be typos, word usage, terms, punctuation, and image placement. The main aspects to be evaluated, namely: the suitability of the elements of the lesson plan, the suitability of the contents/learning material, the suitability of the lesson plan, and LKPD with the Constructivism Approach. The revision that was made according to the validator's suggestion was implemented in Prototype 2. Prototype 1 was revised based on the validator's suggestion on RPP and LKPD. The mathematics learning tool based on Constructivism Approval was validated by 2 experts. Prototype 3 was the result of a revision of one-to-one evaluation of the developed learning tools. The one-to-one evaluation was an individual evaluation carried out by asking students for advice to assess the LKPD that has been produced. The purpose of this individual evaluation was to identify possible errors.

The evaluation was based on the students' comments on the designed LKPD. LKPD was given to three eleventh graders of SMA N 2 Lubuk Basung with good, medium, and poor ability. The three students were asked to study LKPD; after that, they were required to provide comments on LKPD that were given both about the wrong spelling, observing the instructions that were difficult to understand, sentences that were difficult to understand, punctuation marks, the suitability of the examples, the contents of the material, and usability. After prototype 3 was completed by students, interviews were conducted with students regarding prototype 3. The evaluation was that the three students could understand every instruction or command and the purpose of the questions that existed in LKPD.

Mathematics RPP based on the constructivism approach was considered valid through observation done by the validator. The observed aspects were RPP component in the form of RPP identity aspects, competency achievement’s indicators, objectives of learning, teaching topic, approaches of learning, learning strategies and methods, learning activities’ steps, resources of learning, assessment, language, and the benefits of the RPP. For the RPP component aspects, the validity value obtained was 0.95 with a valid category.

The learning device was valid if the learning device developed was based on the device development procedure and has been validated by a validator with a valid assessment and provides recommendations for use [22]. A valid lesson plan was expected to be used by teachers as a guideline in the learning activities to drive students to learn and help in understanding mathematical concepts. The teacher must plan activities that needed to be done so that the teacher's task runs optimally [18].

The validity criteria developed by the LKPD were in terms of content and construct. Mathematics LKPD based on the constructivism approach was considered valid if it satisfied several observed aspects, namely the presentation, content eligibility, graphic or display, and language. In terms of presentation, LKPD based on the constructivism approach, has valid criteria with a validity value of 0.96. In general, LKPD structure consisted of the title, study instructions, competencies to be achieved, supporting information, tasks and work steps, and assessment [22].

LKPD also contained clear learning instructions, where learning instructions were teachers and students' guide in using LKPD in the learning process. Study instructions should be arranged using language that was easily understood and as per the cognitive level of students. LKPD must contain all instructions needed by students, and the instructions were written in the simple form with short sentences and vocabulary that were appropriate to the user's age and ability [23].

4. Conclusion
Based on the research explained above, it can be concluded: (1) Learning tools in the form of RPP and LKPD based on the constructivism approach are valid. (2) Learning tools in the form of RPP and LKPD based on the constructivism approach are practical.
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