Development of mathematical learning tools to promote higher order thinking skills for elementary school students

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Abstract. As stated in the revised curriculum 2013 or K-13 in 2017, the learning tools made by a teacher must bring up and involve 4 (four) aspects, namely Character Education Strengthening (KDP), Literacy, 4C, and Higher Order Thinking Skills (HOTS). Therefore, teachers are required to have sufficient knowledge in these four points, in order to be able to grow their creativity to mix and make it happen in the form of a complete learning device. This research is a design research that aims to describe the process and results of the development of HOTS-based mathematics learning devices that meet the criteria of valid, practical, and effective. The learning devices developed in this study are in the form of lesson plan, student worksheet, and assessment sheet. To develop the product, the researchers implemented Plomp development model, which includes the initial research stage, design/prototype stage, and assessment stage. The results of data analysis show that HOTS-based mathematics learning tools for elementary school students developed by the researchers meet the criteria of valid, practical, and effective, with a mean score as the following: Lesson Plan (3.41), Student worksheet (3.39), Learning outcomes (3.73), Learning feasibility (4.03), Positive student responses (94.44%).

1. Introduction
One of the efforts made by the government to improve the quality of education in Indonesia is to revise the 2013 Curriculum (which will henceforth be called "K-13") on an ongoing basis. At a practical level, K-13 is carried out in the classroom in the form of learning tools made by the teacher. In Permendikbud number 22 of the year 2016 concerning process standards of elementary and secondary education, it is stated that one of the four aspects that must be strengthened in the classroom is Higher Order Thinking Skills (HOTS) [1]. Therefore, teachers are required to have sufficient knowledge in this point, in order to be able to grow their creativity to mix and make it happen in the form of a complete learning tool [2].

Higher-order thinking is a higher level than memorizing the facts or something back to someone exactly the way it was told to you [3]. It is also described as the ability to think critically, logically, reflective, metacognitive, and creative thinking which is a high-level thinking ability. Higher-order thinking skills are valued because they are believed to better prepare students for the challenges of adult work and daily life and advanced academic work. A curriculum emphasizing higher-order thinking skills has been found to be substantially increased [4].

Higher-order thinking requires students to manipulate information and ideas in ways that transform their meaning and implications. The student's transformation occurs in order to synthesize, generalize, explain, hypothesize or arrive at some conclusion or interpretation. Manipulating information and ideas through these processes allows students to solve problems and understandings. When students engage in the construction of knowledge, an element of uncertainty is introduced into the instructional process and makes instructional outcomes not always predictable; i.e., the teacher is not certain what
will be produced by students. In helping students become producers of knowledge, the teacher's main instructional tasks are to create activities or environments that allow them opportunities to engage in higher-order thinking [4].

In 2017 national exam, Higher Order Thinking Skills (HOTS) questions began to raise. By analyzing the news in printed mass media, internet-based media, and electronic media, it can be seen that many students have difficulty working on HOTS questions. There is even a collection of negative student comments about HOTS questions that are viral on social media. The application of several learning models as stated in the revision of K-13 such as project-based learning, problem-based learning, learning with problem solving approaches, discovery/inquiry, provide opportunities for teachers to implement learning activities at the HOTS level. Therefore, teachers are required to have ability to design and implement it in class. In order for teachers to carry out learning that supports HOTS, they need learning tools which are also based on HOTS. In accordance with the results of previous study conducted by the researchers, it was revealed that teachers were still confused in designing learning tools that promote HOTS, especially teachers at elementary school level [5].

Improving high-level thinking skills has become one of the priorities in school mathematics. Permendikbud number 21 of the year 2016 concerning basic and secondary education content standards states that mathematics subjects are given to all students to equip them with the ability to think logically, analytically, systematically, critically, and creatively, and the ability to cooperate [1]. In this document, it is also emphasized that the learning of school mathematics aims that students have problem-solving skills including the ability to understand problems, design mathematical models, complete models and interpret solutions obtained. How do teachers facilitate students to become thinkers and problem solvers better? The answer is simple, namely to make mathematics classes as a place for students to develop their thinking skills.

Teaching thinking skills is based on two philosophies. First, there must be specific material or lessons about thinking. Second, integrating thinking activities into each mathematics learning. Thus, thinking skills, especially high-level thinking, must be developed and become part of everyday mathematics. With this approach, thinking skills can be developed by helping students become better problem solvers. For this reason, the teacher must provide mathematical problems that enable students to use high-level thinking skills.

A teacher may use the Bloom taxonomy of educational objectives or the revised one [6] to view the types of thinking skills which consist of lower order or higher order thinking skills. Some experts argue that Lower Order Thinking Skills (LOTS) includes knowledge, understanding and application; while HOTS includes analysis, evaluation, and create. HOTS places greater emphasis on the process: Transferring facts from one context to another; Select, process and apply information; Seeing the relationship between several different information; Using information to solve problems; and test information and ideas critically [3], [7].

In short, the aim of this study is to describe the process and the result of development of mathematical learning tools based on higher order thinking skills for elementary school students, which satisfy the criteria of validity, practicality, and effectiveness.

### 2. Method

This study is a design research, that is oriented to the development of theory or product, with an interactive and cyclic development process, which enables developer ideas that are theoretical can be realized in the form of products which are tested theoretically and empirically [8], [9]. The development model used in this study is the one proposed by Plomp [9], [10] while the criteria of product quality development is the one created by Nieven [11], [12]. Thus, the purpose of this study is to describe the process and results of the development of mathematical learning tools based on higher order thinking skills for primary school students who meet the criteria of valid, practical and effective. The Plomp model of development is selected by the researchers because it is commonly used to develop educational products, and the research design has clear and systematic procedures.

Regarding the product quality criteria, it is said that product quality or development results can be determined based on validity, practicality, and effectiveness [11], [12]. The effectiveness of HOTS-based mathematics learning devices in this study can be achieved if (1) experts and practitioners based
on their experience state that HOTS-based mathematical learning devices that are developed can achieve the stated goals, and (2) the implementation gives results in accordance with expectations, namely, fulfilling components of the implementation of teacher instruction tools, students’ achievement, students’ responses, and teacher responses during interviews.

The component of the implementation of learning devices is fulfilled if the teacher conducts a mathematics instruction according to the steps written in the Lesson Plan, and can be categorized as “good.” In addition, the components of learning outcomes are met when students succeed in achieving mastery learning. It means that a minimum of 85% of the total number of students who become the research subjects master a minimum of 80% of the material provided. Besides, the student response component is fulfilled if at least 75% of the respondents give a positive response to the learning process that uses HOTS-based learning tools, and have the knowledge, attitudes and skills that have been set. Furthermore, the teacher response component is fulfilled if the teacher gives a positive response to the learning tools, which is revealed in the interview.

The research instruments used in this study consist of instruments to validate the learning tools, instruments to see the practicality of learning tools, and instruments to see the effectiveness of the device if implemented in a mathematics classroom. The instruments used to validate devices are arranged in accordance with the curriculum. For this purpose, the measurement is carried out by a questionnaire in the form of rating and qualitative advice from experts for the consideration of device revisions. The validity of the learning device is indicated by the scores obtained from the results of filling the validity sheet of the device by experts. The measurement scale uses a Likert scale model with 4 points, namely 1, 2, 3, and 4.

In addition, the instruments used to assess the practicality of the learning device are carried out by observation sheet of the device implementation whether intended to determine the implementation of the learning device, or to find out the constraints faced. The observation sheet given is in the form of a rating that will be processed quantitatively, while the suggestions are used for the purposes of considering device revisions.

The instruments for measuring the effectiveness of the developed learning devices were based on the ability of students to solve mathematical problems which fulfill the characteristics of higher order thinking skills. The data obtained were then analyzed to answer the research objectives, namely to produce mathematical learning devices that met the criteria of validity, practicality, and effectiveness. Data in the form of comments, and suggestions were analyzed qualitatively, which were then used as input to revise the products developed. Data in the form of rating (quantitative data) with a scale of 5 are converted into qualitative form.

3. Results and Discussion

In *Permendikbud* number 22 of the year 2016 concerning process standard of elementary and secondary education stated that the preparation of learning tools is part of instruction planning. This instruction planning is designed in the form of syllabus and lesson plans that refer to content standards. In addition, the instruction planning is also carried out in preparing media and learning resources, assessment tools, and learning scenarios. In this study, the learning tools developed consist of (a) Lesson Plans (LP), Student Worksheet (SW), and Assessment Sheet (AS) along with the answer key. The initial design of such learning tools were called prototype-1. Then, these prototypes were evaluated by two experts, both in the field of mathematics education, and the development of learning tools. This step is also called validity test. The results of lesson plan evaluation by experts can be seen in the following table.
Table 1. Results of expert appraisal of lesson plan

| Assessment Aspect                                      | Validator 1 | Validator 2 | Mean | Criteria |
|--------------------------------------------------------|-------------|-------------|------|----------|
| **A. Implementation of Learning**                      |             |             |      |          |
| Completeness of Lesson Plan identity                   | 4           | 5           | 4.5  |          |
| Clarity of core competencies and basic competencies    | 4           | 5           | 4.5  |          |
| Compatibility of core competencies and basic competencies with learning objectives. | 4           | 4           | 4    |          |
| Suitability of indicators with learning objectives      | 4           | 4           | 4    |          |
| Conformity of teaching material with learning objectives| 4           | 4           | 4    |          |
| Deteriorating teaching material.                        | 4           | 4           | 4    |          |
| The accuracy of the use of interaction designs in learning | 4   | 4           | 4    |          |
| Clarity of the stages of learning activities (introduction, core activities, and concluding activities) | 4   | 4           | 4    |          |
| Compatibility of learning objectives with selected learning strategies (approaches and methods) | 4   | 4           | 4    |          |
| Accuracy of learning steps in achieving learning objectives | 4   | 4           | 4    |          |
| **B. Time Management Category**                        |             |             |      |          |
| Suitability of time allocation used                     | 4           | 4           | 4    |          |
| Details of time for each stage of learning.             | 4           | 4           | 4    | 4.08     |
| **C. Category of Readability**                         |             |             |      |          |
| Use good and correct Indonesian language rules.        | 2           | 3           | 2.5  |          |
| Accuracy of sentence structure.                        | 3           | 3           | 3    | 3.41     |
| **General Assessment**                                 |             |             |      |          |
| General assessment of lesson plan                       | B           | B           | 3.41 | Good     |

Based on the results of validity test for lesson plan, it can be said that the lesson plan developed in this study get a mean score of 3.41, which is included in “good” category. Regarding the results of expert appraisal of student worksheet, we may see the following table.

Table 2. Results of expert assessment of student worksheet

| Assessment Aspect                                      | Validators I | Validators II | Mean |
|--------------------------------------------------------|--------------|---------------|------|
| **A. Instructions**                                   |              |               |      |
| Instructions on LKS can help students solve the given realistic problems and construct knowledge. | 4            | 4             | 4    |
| **B. Content**                                        |              |               |      |
| Conformity between content of student worksheet and learning objectives. | 4           | 4             | 4    |
| Clarity of the problems presented in the student worksheet. | 5           | 5             | 5    |
| The given problems are related to daily life.          | 5           | 5             | 5    |
| Be able to encourage students to make their own models / ways. | 4           | 4             | 4    |
| Be able to help students connect several concepts.     | 4           | 4             | 4    |
| Be able to help students construct concepts through daily problem solving. | 4           | 4             | 4    |
| Mean                                                   |              |               | 4.29 |
| **C. Readability**                                    |              |               |      |
| The language used is in accordance with the level of student development, so that it is easy to understand. | 3           | 2             | 2.5  |
| Using a choice of words that are clear and do not contain multiple meanings. | 3           | 2             | 2.5  |
| Mean                                                   |              |               | 2.5  |
| **General Assessment**                                 |              |               |      |
| Criteria                                               | I            | II            |      |

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In Table 2, we can see that the general assessment of student worksheet is also in “good” category. This result is supported and strengthened with the suitability of student activities with the ideal time which is shown in the following table.

Table 3. Suitability of Student Activities with Ideal Time in Mathematics Lessons

| Student Activities                              | Tolerance  | Meeting |
|-------------------------------------------------|------------|---------|
| Read and understand contextual problems carefully. | 1% ≤ P ≤ 11% | 8.00 8.39 8.19 8.24 |
| Think and work individually.                    | 1% ≤ P ≤ 11% | 7.20 6.99 6.29 6.59 |
| Ask the teacher because he does not understand. | 1% ≤ P ≤ 11% | 10.40 6.99 7.55 7.69 |
| Create a self-developed model.                  | 7% ≤ P ≤ 19% | 12.80 16.78 12.58 15.37 |
| Resolve contextual problems individually.       | 3% ≤ P ≤ 11% | 3.20 4.20 5.05 5.49 |
| Compare and discuss answers based on self-developed models. | 10% ≤ P ≤ 20% | 19.20 15.38 15.09 13.74 |
| Express opinions.                               | 7% ≤ P ≤ 17% | 17.60 16.78 16.35 14.29 |
| Listen to the opinions of others.               | 4% ≤ P ≤ 14% | 8.80 8.39 10.06 9.89 |
| Compare and test different answers.             | 3% ≤ P ≤ 11% | 4.00 4.20 4.40 4.40 |
| Negotiate, in a sense that is not a priori about the opinions of others. | 1% ≤ P ≤ 11% | 2.40 3.50 4.40 4.95 |
| Check and modify your own answers, when looking at other students’ problem solving methods. | 1% ≤ P ≤ 11% | 3.20 4.20 5.03 4.40 |
| Draw conclusions and make material summaries in his/her own book | 1% ≤ P ≤ 11% | 3.20 4.20 5.03 4.95 |

In Table 3, it can be seen that all student activities (100%) are included in the ideal time tolerance limit, while the three most dominant student activities are to compare and discuss answers based on the self-developed models, followed by expressing opinions, and creating self-developed models. This is in line with the principles and characteristics of realistic mathematic education, which provides broad opportunities for students to construct mathematical knowledge through individual learning, small group learning and learning in classroom settings [21], [22]. By making student’s own model, then discussing and comparing answers based on the model, it means that students have critical thinking maybe even thinking creatively if there is an element of novelty in the model made by students. This can also be categorized as higher order thinking skills as the students implement the three upper levels of Bloom taxonomy, namely, synthesis, evaluation and create. Based on the criteria set out in the preceding section, the activities of students in this study are included in the effective category.

Data of student response were obtained using questionnaire of student response, which were consisted of 18 questions or statements. Among the 21 students who were given questionnaire of students’ response, only 18 students returned the questionnaire. From the results of the recapitulation of student answers to questions or statements in the questionnaire, the researchers revealed that 17 of 18 questions/ statements in the questionnaire received very positive responses from students with a percentage of 94.44%. There are only 1 (one) question that got a positive response of 70.59%, which means that some 70.59% of students think that the questions given are easy to handle. Based on predetermined criteria, student responses fall into a very positive category.

4. Conclusion

This study aims to describe the process and results of the development of mathematical learning devices based on Higher Order Thinking Skills (HOTS) that meet valid, practical, and effective criteria. The results of this development are in the form of Lesson Plan (LP), Student Worksheet (SW)
and Assessment Sheet (AS). Based on the development process, the data analysis, as well as the limited trial of the learning tools, it can be summarized as follows. The HOTS-based mathematics learning tools in statistical material meet valid criteria, because it is supported by the following information. The HOTS-based Lesson Plan meets valid criteria with an average score of 3.41; the HOTS-based student worksheets satisfy the valid criteria with an average score of 3.39; and the assessment sheets meet the valid criteria with an average score of 3.73.

HOTS-based mathematics learning tools in statistical material meet the practical criteria with the following description. (1) Assessment using validation sheets given by two validators who were experts in mathematics education, state that the learning tools can be used with small revisions; (2) The results of the implementation or limited trial of the learning tools got a score of 3.88 at the first meeting which was included in good category, while for the second meeting got a score of 4.47 which was included in very good category. It means that the overall learning implementation score for the two meetings is very good with an average score of 4.18; (3) The activities of students in the first and second meetings are still at the tolerance time limit of 5% so that the effectiveness of student activities is fulfilled; (4) The response given by students to the questionnaire given, and the limited trial of the learning tools showed a positive response of 94.44% which is included in very good category.

Among 21 student learning outcomes in Quiz 1, there were 2 (two) students (9.52%) who did not complete, because they did not meet the Minimum Learning Completeness, that is 80 (eighty). However, this condition did not continue in Quiz 2, because 100% of students were successful in achieving the Minimum Learning Completeness (MLC). It also means that classical learning completeness has been fulfilled.

From the description above, it can be concluded that HOTS-based learning tools in statistical material for elementary school students developed by the researchers meet the criteria of valid, practical, and effective. Based on these conclusions, the researchers suggest that the development of this learning tools can be used as a reference in conducting other relevant development research. Because in this study the researchers implemented the approach of realistic mathematics education in developing the learning tools, we may suggest that any future research in this field would be based on higher order thinking skills, but implement other models of learning, such as problem-based learning, project-based learning, discovery learning, cooperative learning, and any other models.

5. References

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