The development of student worksheets based on higher order thinking skill for mathematics learning in junior high school

Sutama¹, Harun Joko Prayitno², Sabar Narimo³, Naufal Ishartono⁴, Diana Purwita Sari⁵

¹-⁵) Mathematics Education Department, Universitas Muhammadiyah Surakarta, Indonesia

Corresponding author: sutama@ums.ac.id

Abstract. There are three purposes of this study. 1) to develop student worksheets based on Higher Order Thinking Skills (HOTS); 2) to test the feasibility of developed student worksheets, and 3) to analyse student assessments of developed worksheets. This research is a research and development (R&D). The development model is ADDIE which consists of 5 stages, namely Analysis, Design, Development, Implementation, and Evaluation. The study was conducted at SMP Negeri 1 Karanganyar in the academic year of 2018/2019. Data collection was obtained through observation, interviews, documentation, and questionnaires. Data analysis techniques used was critical analysis and comparative descriptive analysis. The results of the research were 1) This research and development had produced a worksheet based on HOTS on the subject of algebra; 2) Student worksheets developed were declared valid by experts and education practitioners, and 3) The results of the students' responses showed that the student worksheets that had been developed were interesting and the questions of HOTS presented were quite challenging to solve. Thus, students' worksheets based on developed HOTS were suitable to be used in mathematics learning.

Keywords: higher order thinking skill, student worksheet, mathematics

1. Introduction

Education plays an important role in facing the challenges of the industrial revolution 4.0 era. That era is a globalization era in which information and communication technology grows faster and triggers the advancement of science. One of the education problems in Indonesia is about the ability of Indonesian students to compete with students in other countries. It is reflected from the results of the analysis of students' abilities achievement in several International researches such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA).

The TIMSS study of 2015 attended by Indonesian students obtained low results when it was compared to other countries. Results of mathematics competence, Indonesia ranked 45th out of 50 countries with a score of 397 [1]. While in the field of science, Indonesia got a score of 397, ranks 45th out of 48 countries. These conditions are relevant to the PISA results in 2015 followed by
students aged maximum 15 years (equivalent to junior high school), Indonesia got a score of 386 for
mathematics. It places Indonesia on 64th place out of 72 participating countries in PISA [2].

Questions developed by TIMSS and PISA require students to think at a higher level. The results
of the TIMSS and PISA showed that students in Indonesia tend to master routine questions, simple
computing, and measure knowledge and facts in contextual contexts. This is because educators in
implementing learning are more focused on the use of learning strategies and how to create an active
learning atmosphere, but less emphasis on abilities and skills in problem-solving [3]. So, things that
should be the concern of educators, is about the students that need to be given the reinforcement
related to the ability to integrate information, draw conclusions, and generalize knowledge possessed
in other contexts (not just routine problems).

The results of the pre-survey conducted by the researcher at SMP Negeri 1 Karanganyar showed
that students were able to work on memorization type questions well, but they were not optimal in
terms of the ability to analyze and evaluate. The results were observed from the analysis of the score
documents which showed that students' scores in mathematics were the lowest when it was compared
to other subjects. This should be a concern for educators, especially mathematics teachers. Learning
mathematics, in essence, is not to master knowledge, but to build competencies (Sari, Usodo, &
Subanti, 2018). This is because the era of the industrial revolution 4.0 requires students to master basic
literacy (science, mathematics, reading, and technology), as well as the skills of critical thinking,
creative, communication, collaboration, and characters [4][5].

The tendency of Junior High School mathematics teachers is getting difficulties in authentic
assessment for higher-order thinking. The same thing is stated by the Ministry of National Education
[6] that the achievement of mathematics achievement which is classified as low, one of them is due
to the habit of assessment in Indonesia which is oriented to measure the lower order thinking skills
(LOTS), students have not been optimally trained for higher order thinking skills (HOTS). Krathwohl
state that the HOTS indicators include the ability to analyze (C-4), evaluate (C-5), and create (C-6)[7].
These higher-order thinking skills accustom individuals to apply new information or prior knowledge
and to manipulate information so that they can find possible answers in new situations [8].

The development of mathematical competencies is directed to improve life skills, especially
building creativity, critical thinking skills, collaboration and communication skills that are becoming
demanded skills in the industrial revolution 4.0. High-level thinking skills will not be achieved by
itself without the effort and supporting facilities. Ministry of National Education Regulation
(Permentiknas Nomor 16 Tahun 2007) concerning Academic Qualification Standards and Teacher
Competency states that there are two competencies that must be possessed by educators in the
pedagogical dimension including able to develop indicators and assessment instruments and be able to
develop learning design components. Therefore, educators must have creativity in learning that is able
to facilitate students to learn actively and independently. One of the ways that can be done is
developing a HOTS-based on student worksheets.

Researchers followed up the results of the pre-survey in SMP Negeri 1 Karanganyar by filling a
questionnaire for students and educators. The facts obtained based on the results of the teacher's
questionnaire were that teaching materials were sufficient, but the student worksheet components used
were only in the form of questions, it did not clearly list the capabilities developed and there were no
structured steps to find basic concepts. This result was strengthened by an interview with one of the
educators who explained that he had never developed a HOTS-based student worksheets. The
questionnaire results of students proved that the student worksheets used in learning were less
interesting, so the motivation of students to learn mathematics was not optimal yet.

Based on the facts that have been stated above, the problem needs to be fixed with the right
strategy, including helping students to train and to improve higher-order thinking skills. One of the
efforts that can be done is developing a HOTS-based student worksheets to facilitate and to guide students so that they have higher order thinking skills.

2. Method
This research is research and development (R&D). Research and development is a process or steps to develop new products or improve existing and accountable products [9]. The study was conducted at SMP Negeri 1 Karanganyar in the academic year of 2018/2019. The development model was conducted by applying ADDIE model which consisted of 5 stages, namely Analysis, Design, Development, Implementation, and Evaluation [10]. The details of the activities carried out at each stage are illustrated in Figure 1.

| A | Analysis
Conduct needs analysis, curriculum analysis, and literature study. |
| --- |
| D | Design
Design the initial draft of the student worksheet, design a validation questionnaire instrument, and design the blueprint of the items. |
| D | Development
Develop student worksheets based on the initial draft that will be validated by experts and education practitioners. |
| I | Implementation
Conduct limited trials and field trials (the aim is to find out students' responses to student worksheets that have been developed). |
| E | Evaluation
Analyze of the assessment of student worksheets (the goal is to know whether the student worksheets need to be improved or appropriate to be used in learning). |

Figure 1. Activities at each stage of research and development (R&D)

Data collection was conducted through observation, interviews, documentation, and questionnaires. The measurement of the questionnaire used Likert scale with a weighting of five scales, which was very feasible (score 5), feasible (score 4), less feasible (score 3), not feasible (score 2), and very improper (score 1). This research and development data consisted of qualitative and quantitative data. Qualitative data in the form of criticism and suggestions from material experts, media experts, practitioners, and respondents, were analyzed using critical analysis. Quantitative data in the form of assessment results of student worksheets conducted by material experts, media experts, practitioners, and respondents, were analyzed using a comparative descriptive analysis.

3. Result and Discussion
The results of this research and development are HOTS-based mathematics student worksheets on the subject of algebra. The development of this worksheet aims to train students' skills to solve HOTS questions on algebraic material. The research results of each stage are explained as follows.

Analysis Stage
Activities carried out at this stage, namely needs analysis and curriculum analysis that were done through interviews and observations to one of the mathematics teachers at SMP Negeri 1
Karanganyar. The results of the needs analysis found that the teacher had not used HOTS-based student worksheets when learning mathematics. This was due to several factors, including limited references to make HOTS questions so that the problems presented during learning were limited to textbooks.

The results of the curriculum analysis found that the school used the 2013 curriculum. Based on Permendikbud Number 24 Year 2016 concerning core competencies and basic competencies of junior high schools, it was found that the basic competencies of material about algebra in class VII include:

a. KD (Basic Competence) 3.5 explains algebraic forms and operates on algebraic forms (addition, subtraction, multiplication, and division);

b. KD (Basic Competence) 4.5 resolves problems related to algebraic forms and operations on algebraic forms.

**Design Stage**

In the design stage, the researcher designed the initial draft of a HOTS-based student worksheet, including designing the cover, compiling a validation questionnaire instrument, compiling a blueprint of questions, and compiling a student worksheet assessment instrument that will be developed. The feasibility instruments for student worksheets that the researcher designed were the validation sheet for material experts and media experts, practicality assessment sheets, and student response questionnaire sheets. The draft component of the student worksheet developed by the researcher consisted of the title, study instructions, competencies to be achieved, supporting information, practice questions, and assessment. The draft is presented in Figure 2.

**Figure 2.** The draft of student worksheet based on HOTS
The HOTS questions in this student worksheet were arranged through some steps: analyzing basic competencies; arranging the blueprint; choosing interesting stimuli for each question; writing questions according to the blueprint, and establishing scoring guidelines. HOTS questions that were presented on this student worksheets consisted of 8 items of C-4 (analyze) questions, 6 items of C-5 (evaluate) questions, and 6 items of C-6 (create) questions with details of 10 questions presented in the form of multiple-choice, and 5 questions presented in the form of essays.

**Development Stage**

At this stage, the researcher developed student worksheets based on a draft that had been designed in the previous stage, and then the worksheet was validated by material experts and media experts. The experts provided suggestions for improvements related to the use of language to make it easier for students to understand. The researcher then revised the student worksheets according to the advice of the expert. The researchers also validate the product with education practitioners (in this case the teacher). HOTS questions on valid algebraic material can be seen in Figure 3.

![Figure 3. HOTS questions on algebraic material](image)

**Implementation Stage**

At the implementation stage, students' worksheets were trialled to find out student assessments of the student worksheets that had been developed. There were two trials at this stage, namely a limited trial involving 6 students of 8th grade, and a field trial involving 28 students of 8th grade. In the limited trial stage, HOTS-based student worksheets were declared eligible so that they could be continued for wider trials (field trials). Field trials provided results that HOTS-based student worksheets based on an assessment obtained from the students’ response questionnaires were suitable to be applied for learning algebra.

**Evaluation Stage**

Evaluation is the result of an assessment of a student worksheet that has been developed. At this evaluation stage, the assessment is obtained based on the results of the validation of experts, education practitioners (teachers), and students’ responses (based on questionnaires). The results of the feasibility assessment of HOTS-based student worksheets are presented in Table 1.

| No. | Experts          | Average total score |
|-----|------------------|---------------------|
| 1.  | Material Expert  | 4.8                 |

Table 1. The results of the feasibility assessment of HOTS-based
Table 1 showed that HOTS-based student worksheets that had been developed were suitable to be used in learning. So, the product that had been developed can be used as an alternative in learning mathematics in Junior High School.

The results of this research and development, namely HOTS-based mathematics student worksheet on the subject of algebra. This research was conducted to equip students so that they are familiar with HOTS-based exercises. This was because HOTS-based questions could improve students' critical thinking skills [11].

At the analysis stage, the researcher carries out a needs analysis, curriculum analysis, and literature study. This analysis activity aims to find out what teachers and students need in learning. Needs analysis is a priority scale for choosing the right action in overcoming learning problems [12]. The results of the needs analysis found that the teacher had not used HOTS-based student worksheets when learning mathematics. Student worksheets are an important component of learning. This is because the worksheets could encourage students' creativity to be able to solve the problems given [13]. The researcher also carry out curriculum analysis at the research site. This was because of the curriculum as a tool to achieve educational goals as well as guidelines in the implementation of education [14]. So, the researcher needs to adjust the products to be developed with the curriculum used in schools. A literature study is also needed at this stage. This is because the researcher needs many references to be able to develop products in this research and development.

In the design stage, researchers designed the initial draft of a HOTS-based student worksheet. HOTS questions that would be arranged were diverse (in the form of multiple-choice and description) and were able to measure students' critical thinking skills. The researchers needed to pay attention to the practical aspects at this stage. This is because student worksheets are needed in order to encourage students to be more actively involved individually or in groups in the learning process, especially in observing, investigating, drawing conclusions from the data provided, and drawing hypotheses [15].

The researcher continued the initial draft design (at the design stage) into the development stage. At this stage, three activities were carried out, including developing and validating student worksheets, and revising student worksheets based on input from experts. This research examined the feasibility of the product in terms of the appropriateness of the content, appearance, and language adapted from the duties of the National Education Standards Agency. In this case, the product quality is said good if it meets the valid and practical aspects [16]. Feasibility assessment of the product that was done by experts and practitioners (teachers) showed that the student worksheets developed were suitable to be used in the research. The results of this validation are important. This is because the research instrument must be valid as the instrument has a major influence on drawing conclusions of a study [17].

At the implementation stage, the researcher carried out product trials (in this case student worksheets). This trial was conducted to determine students' responses to the product being developed. Product trials are activities to find out the quality of the product before it is used in the actual application [18]. The results of student responses in the form of a questionnaire proved that the student worksheets that had been developed were interesting and the HOTS questions presented were quite challenging to be solved.
The final stage in this development research is the evaluation stage. The evaluation stage aims to measure the feasibility of the student worksheet that was developed. Based on the results of validation that were conducted by experts and the responses from students, HOTS-based student worksheets were suitable to be used in learning mathematics. This worksheet is expected to support learning activities which in turn has a positive impact on student mathematics learning outcomes. This is because the use of appropriate student worksheets could optimize student learning outcomes [19].

4. Conclusion

This research and development had produced a worksheet based on HOTS on the subject of algebra. Student worksheets developed were declared valid by experts and education practitioners. The results of the students' responses (by filling a questionnaire) showed that the student worksheets that had been developed were interesting and the questions of HOTS presented were quite challenging to solve. Thus, students' worksheets based on developed HOTS were suitable to be used in mathematics learning.

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