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Development of Student Worksheets-Based Guided Discovery with a Scientific Approach to Improve Mathematical Connection Ability

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Abstract

The purpose of this study was to develop student worksheets-based on guided discovery with a scientific approach to improve students' mathematical connection ability. The criteria for developing student worksheets are valid, practical, and effective. Type of research is research and development with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The research subjects were grade 7A junior high school 2 Pulokulon. Data collection techniques include product assessment, questionnaires, observations, and tests. Data analysis techniques include validity test, practicality test, and effectiveness test. The results showed that: (1) the student worksheets met the expert validity with a score of 4.4 and were very good, (2) the student worksheets met practicality with a score of 3.16 with a very good category, and (3) the student worksheets are effective for improving students' mathematical connection ability with classical mastery learning outcomes by 77% and increasing abilities with N-Gain = 0.54 in the medium category.

1. Introduction

Mathematical connection ability is an ability that must be developed by students. NCTM (2000) wrote that the standard process of ability in learning mathematics, namely problem solving, reasoning ability, representation ability, connection ability, and communication ability. This means that in learning mathematics students must be equipped with good connection skills. The importance of mathematical connection ability was also conveyed by Susanti et al. (2017) that mathematical connection ability is very important to support the development of students in learning mathematics.

Mathematical connection ability is a basic ability that must be possessed by students in learning mathematics (Jihad, 2008:148). Mathematics consists of several concepts that cannot be separated so that mathematical connections mediate one concept with another concept (Susanti et al., 2017). Haylock & Thangta in Susanti et al. (2016) asserted that mathematical connection refers to the process of students building an understanding of mathematical ideas through awareness of the relationship between real experiences, language, images, and mathematical symbols. Then NCTM (2000) wrote that with mathematical connections students do not need to remember too many separate concepts and skills.

Based on the results of the 2018 PISA (Program for International Students Assessment) survey, it was written that the mathematics scores of Indonesian students had decreased compared to the 2015 PISA, from 386 to 379. These results indicate that students' abilities in mathematics need to be optimized. Furthermore, the results of the 2019 junior high school level national exam (Kapuspendik, 2019) explained that the average junior high school mathematics national exam was only 46.56. This figure is lower than the average value of the natural science national exam, which is 48.79. This means that the ability of Indonesian students in the field of mathematics needs to be optimized. One of these mathematical abilities is the ability to connect mathematically. Furthermore, based on the results of observations and interviews at the research site, the results showed that students' ability to solve problems

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needed to be optimized. Furthermore, students in linking concepts in the same topic, between material in certain topics with the material in other topics, and mathematics with everyday life also still need to be optimized.

The mathematical connection ability has not yet been optimized, so efforts need to be made to overcome this problem. One of them is by using student worksheet-assisted learning that supports mathematical connection abilities. Departemen Pendidikan Nasional (2008:10) wrote that student worksheets should be developed according to student characteristics, curriculum demands, and problem-solving learning.

Trianto (2012:111) wrote student worksheets as a guide for students to carry out a series of problem-solving activities. Student worksheets aim to develop cognitive aspects, experimental aspects, and demonstrations. Furthermore, Ahmadi & Amri (2011: 77) suggested active student worksheets, helping students find concepts, alternative solutions so that students are active and motivated. However, the student worksheets used in learning are not following the needs of students and students are still passive in the learning process.

Muharom (2014:3) wrote that teachers tend to be more active people, so students tend to be passive and feel bored in the learning process. So to activate students and attract students to learn, there needs to be a strategy so that students are motivated to learn (Naibaho, 2012). One of these conditions is by conducting the students worksheets-based guided discovery-assisted learning that focuses students on being active in learning.

Guided discovery is a two-way system that involves students answering the teacher's questions (Hamalik, 2009: 188). Furthermore, Howe & Jones (1993:172) explained that guided discovery is an instructional method that allows and requires more student freedom than direct instruction. Carin (1997) wrote that guided discovery is a model that guides and trains students to be active in learning, gaining knowledge, and building scientific concepts with their discoveries. So that with student worksheets based on guided discovery students can actively find and solve problems with discovery independently.

he guided discovery itself is supported by the development of mathematical connection abilities (Susanti et al., 2017). If students can understand concepts well through knowledge building, students will easily remember and make connections between concepts in subsequent learning. On the other hand, when students remember and relate concepts well, it will help students understand new concepts.

The student worksheets-based guided discovery contain a series of questions that guide students in discovering mathematical principles/concepts. The development of student worksheet-based guided discovery is also based on field findings that the learning process does not always use student worksheets even though each student has their student worksheet. However, the student worksheets that are owned do not support students' mathematical connection abilities so that students still have difficulty in connecting mathematical materials and concepts in other lessons and connecting them with everyday life. In addition, the student worksheets used have colors and designs that are less attractive to students, so they do not encourage students to learn.

Based on the explanation above, research on the development of student worksheets based on guided discovery with a scientific approach is needed to improve mathematical connection ability. The purpose of this study was to test and determine the validity of student worksheets-based guided discovery with a scientific approach to improve mathematical connection skills, to test and determine the practicality of student worksheets-based guided discovery with a scientific approach to improve mathematical connection skills and to test and find out the effectiveness of student worksheets-based guided discovery with a scientific approach to improving mathematical connection skills.

2. Methods

This research was research development or Research and Development (R&D). Putra (2011: 67) wrote that R&D research is deliberate, systematic research to find, improve, develop, test the effectiveness of products, certain models that are superior, new, effective, and productive.

This research produces a product in the form of student worksheets based on guided discovery with a scientific approach to improve mathematical connection skills. This research was conducted in a junior high school with the research subjects being grade 7 students at junior high school 2 Pulokulon.

This study used the ADDIE model developed by Dicki and Carry (Mulyatiningsih, 2012: 200). The steps taken are analysis, design, development, implementation, and evaluation.

The analysis phase begins with conducting an assessment of previous research, conducting needs analysis, curriculum analysis, and analyzing student characteristics. The design phase begins with preparing product designs on paper, collecting references, and compiling research instruments. The product development stage that has been prepared is developed and creates an instrument to measure product performance by conducting expert validation and product revision. The development stage also aims to test and determine the quality of the developed product. In the implementation stage, at this stage, the product that has been developed is tested on a limited number of students and aims to test and find out the effectiveness and practicality of the product developed to improve students' abilities. The last stage is the evaluation stage to analyze the results of product trials to be revised if there are deficiencies.

The research instruments used in this study were assessment sheets, student response questionnaires, observation sheets, mathematical connection ability test questions. Indicators of mathematical connection ability as written by Sugiman (2008: 64) are (1) inter-topic mathematical connections that link concepts or principles in the same topic, (2) connections between topics in mathematics that link the material in a particular topic with the material in other topics, (3) connections between the material and sciences other than mathematics, (4) connections with everyday life that may be encountered.

Data analysis techniques include validity testing to determine the validity of the developed product, practicality test to determine the practicality of the developed product, and effectiveness test to test the effectiveness of student worksheets to improve students' mathematical connection skills. The guidelines for assessing the tightness and practicality test use the guideline developed by Widoyoko (2016: 238). To determine the level of remaining mathematical connection ability, the category of mathematical connection ability level developed by Nopriyanti (2015).

Table 1. Interval and Criteria of Tightness and Practicality Test

Interval	Criteria
$X > (\bar{X}_i + 1{,}8\ sb_i)$	Very Good
$(\bar{X}_i + 0{,}6\ sb_i) < X \leq (\bar{X}_i + 1{,}8\ sb_i)$	Good
$(\bar{X}_i - 0{,}6\ sb_i) < X \leq (\bar{X}_i + 0{,}6\ sb_i)$	Sufficient
$(\bar{X}_i - 1{,}8\ sb_i) < X \leq (\bar{X}_i - 0{,}6\ sb_i)$	low
$X \leq (\bar{X}_i - 1{,}8\ sb_i)$	Very low

To determine the level of remaining mathematical connection ability, the category of mathematical connection ability level developed by Nopriyanti (2015).

Table 2. Level of Mathematics Connection Ability Criteria

Score	Level of Mathematics Connection Ability
76 – 100	Very Good
51 – 75	Good
26 – 50	Sufficient
0 – 25	Low

The student worksheets-based guided discovery with a scientific approach are said to be valid if they reach the minimum criteria that are good. The student worksheets-based guided discovery are said to be practical if they reach the minimum criteria are good. And student worksheets are said to be effective if the criteria achieved are at least good.

3. Results & Discussions

The research developed student worksheets based on guided discovery with a scientific approach using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The

analysis phase of the researcher conducted an assessment of several previous studies. Some of the previous studies are Cahyani (2014), Mauzana (2016) and Putra (2018). From previous research, it was found that guided discovery-based student worksheets with a scientific approach met the valid, practical, and effective criteria for improving students' mathematical connection skills. Furthermore, the needs analysis showed that students were more interested and happy if learning used student worksheets which challenged students to find proof and solve mathematics on their own, students were less interested and less enthusiastic and tended to be lazy if students were asked to do practice questions, and many students scored high scores. mathematics is still below the minimum completeness criteria.

The main material that will be presented in the student worksheet is the set material. The selected material has been adjusted to the competence, characteristics of students, time, and schedule at school. Based on the above analysis, a student worksheet is needed that can increase students' interest and enthusiasm in learning mathematics with guided discovery so that students are actively involved in finding mathematical concepts/principles. Therefore, guided discovery-based student worksheets with a scientific approach were developed to improve students' mathematical connection skills, especially set material.

The second stage, namely design, includes selecting the format and initial design of student worksheets that are tailored to the needs and characteristics of students. Some things to consider are writing style, the flow of thought, illustrations, paper size, layout, etc. Student worksheets were developed using A4 paper, adding illustrations related to the environment around students so that students make it easier for students to relate to the material, as well as several types of letters so that they are not boring. The contents of this worksheet design include cover, preface, table of contents, basic competency indicators, contents, and bibliography.

The development stage includes the validation and revision stages. Previously, the researcher made a lesson plan to assist the implementation of learning with student worksheets to be developed. The lesson plan is then consulted with the validator and then revised according to suggestions. Then the researcher made a research instrument and validated it to the validator before being used in the study. In addition, the researcher also drafted student worksheets according to the design in the previous stage, then validated it to the validator, for later revision if there were suggestions from the expert team, before then an assessment of the student worksheets was carried out.

After several revisions to the product were made, the student worksheets were assessed in terms of components, conformity with the curriculum, materials, techniques, and language. The validation stage was carried out by two mathematics lecturers and 2 mathematics teachers. The validation results can be seen in the table below.

Table 3. Validation Results

Validation Kind	Score	Criteria
Lesson Plan	4.4	Very Good
Student Worksheets	4.4	Very Good
Test Question Sheet	4.45	Very Good

In table 1 above, it can be seen that the student worksheets, lesson plans, and test questions are valid with scores of 4.4, 4.4, and 4.45 respectively and are in the very good category and can be used.

Several revisions of the development of student worksheets-based guided discovery with a scientific approach include illustrations of pictures and photos that are less nuanced in mathematics, it is necessary to add questions that lead to the development of social skills, time allocation, sentences that need to be corrected so that they are easily understood by students, and some material is not yet visible. clear. The following is an example of improvements to student worksheets.

(a)

3. Berapa banyak mamalia yang ada di kebun binatang Gembira Loka?
Jawab : n(H) =. . . . . .

4. Berapa banyak amphibi yang ada di Gembira Loka?
Jawab : n(I) =. . . . . .

(b)

4. Setelah mendaftar anggota J, banyak anggota J sebanyak 8. Dapat dituliskan n (J) = 8. Bagaimana menuliskan banyak anggota A dan I ?

Jawab : . . . . . .

Figure 1. (a) Question before revision; (b) question after revision.

(a)

(b)

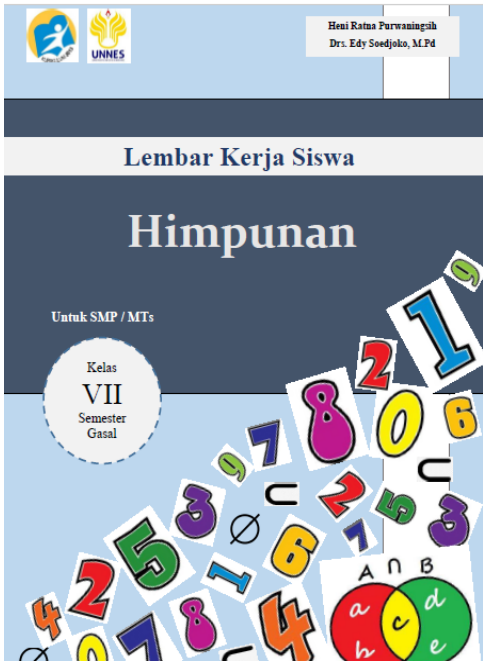
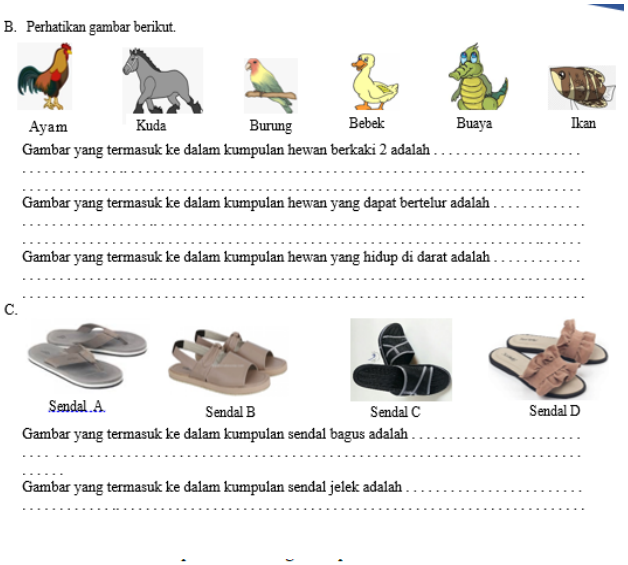


Figure 2. (a) Cover before revision; (b) cover after revision.

Figure 1 shows some of the questions contained in the design for developing student worksheets based on guided discovery with a scientific approach. Figure 1a is an example of a question that was before revision. Based on the expert's assessment, the questions in Figure 1a have not developed social skills and are less varied so that the activities of reasoning and communicating in scientific approach have not been seen. Then the researcher revised as shown in Figure 2b. In Figure 2b the question is corrected by changing the question editor so that scientific approach activities are visible and more varied.

Figure 2a is a cover design of a student worksheets-based on guided discovery with a scientific approach. In the opinion of experts, Figure 2a does not yet show the nuances of mathematics. Then based on this assessment, the researcher made changes by giving a mathematical feel to the cover of the student worksheet, which can be seen in Figure 2b.

(a)



(b)

Figure 3. (a) content before revision; (b) content after revision.

The next development design can be seen in Figures 3a and 3b. Figure 3a is the content on the student worksheets based on guided discovery with a scientific approach before revision. Based on the expert's assessment, some of the questions shown in Figure 3a are not easily understood by students. So with this assessment, the researcher made improvements by changing the sentence of the question so that it was easily understood by students. This can be seen in Figure 3b.

The implementation stage, this stage is testing the products that have been used, conducting learning outcomes tests, and distributing student response questionnaires and learning observation sheets. This student worksheet was tested on the experimental group, namely class 7A of junior high school 2 Pulokulon. Learning using student worksheets runs for 6 meetings and ends with a repetition of the set

material. The purpose of this stage is to determine the practicality of the product and the effectiveness of using student worksheets in learning. The criteria in this study are if students assess the learning materials developed are useful and can be used easily. To test the practicality of using a student response questionnaire. In addition to using student responses, to strengthen the results of learning observations, the results of student response questionnaires and learning observations are as follows.

Table 4. Students Response Questionnaire Results

Questionnaire	Score Average	Criteria
Student response questionnaires	3.16	Very Good

The results of student responses indicate that the student worksheets used are interesting and make it easier for students to understand a material because there are questions that guide students to find mathematical concepts/principles. In addition, there are problems and illustrations related to the environment around students so that students can relate the material to everyday life. This can be proven by students' comments on student questionnaires. In line with Ausubel's learning theory that by connecting new material or knowledge with previous knowledge or matters related to the science, it will provide learning meaning for students. Agra et al. (2019) wrote that meaningful learning is one of the learning strategies informal learning that creates the interaction of new knowledge with relevant old knowledge. In addition, Vygotsky's theory related to the ability to relate the experience of interaction with the surrounding environment will also support the learning process. So that students can connect the material with relevant daily life.

Then the student worksheets involve students' active participation in finding mathematical concepts or principles. Piaget's learning theory that with students active in the learning process it will help the cognitive development of students. Howe & Jones (1995:172) added that guided discovery learning allows students to be actively involved in finding concepts, principles, and solving problems independently through investigation. Hanafiah & Suhana (2000:79) also mentioned the advantages of guided discovery can develop students' cognitive and strengthen students' understanding. Furthermore, it is integrated with a scientific approach enabling students to conduct scientific investigations through questioning, observing, gathering information, reasoning, and communicating.

Furthermore, the implementation of the observation of the implementation of the learning process using student worksheets based on guided discovery with a scientific approach. The results of learning observations can be seen in the following table.

Table 5. Learning Observation Results

Observation	Percentage(%)	Criteria
Learning observation	96	Very Good

From table 5 it can be seen that the average student response score is 3.16 and belongs to the very good category. So it can be said that student worksheet-based guided discovery with a practical scientific approach is used to improve students' mathematical connection skills. Then supported by the results of the observation of the implementation of learning in table 3 shows that the implementation of learning has been going well following the steps of guided discovery with a scientific approach.

At the implementation stage, it is also used to test and determine the effectiveness of guided discovery worksheets with a scientific approach. The results of the learning test showed that 17 students scored above the mastery learning and 5 students scored below the mastery learning. The mastery learning used in this study is 75. So the average student score is 78.6 while the classical completeness is 77%. Based on Nopriyanti (2015) it can be concluded that the level of students' mathematical connection ability is in a good category. These results indicate that the student worksheets-based guided discovery with a scientific approach can improve learning outcomes. Yang et al. as quoted in Simamora et al. (2021) wrote that guided discovery can improve understanding of the concept better. So that student learning outcomes are

also better and in this case also increases the ability of mathematical connections (Susanti et al., 2017). Hiebert & Carpenter in Stylianides & Stylianides (2007) wrote that the level of understanding is determined by the number and strength of connections. NCTM (2000) also wrote that the ability to connect mathematical ideas will increase students' understanding deeper and last longer. Student worksheets facilitate students to connect mathematical ideas with other mathematical topics, with contexts other than mathematics, and everyday life (Mulyani & Muhtadi, 2019).

The scientific approach provides direct involvement of students through observing, asking questions, gathering information, associating, and communicating. Involving students' active roles in learning will improve students' understanding of concepts well (Simamora & Siagian, 2021). Damayanti in Mauzana (2016) wrote that scientific activities contained in discovery-based student worksheets provide direct experience for students to acquire knowledge through independent and active discovery to improve mathematical connection ability.

Furthermore, to test and find out the increase in mathematical connection ability, the N-Gain test is carried out. The N-Gain test uses pretest and posttest values. The results of the N-Gain test can be seen in the following table.

Table 6. N-Gain Results

The average		**N-Gain**	**Criteria**
Pretest	Posttest		
58	78.6	0.54	Medium

Based on table 6, it can be seen that the results of the n-gain test are 0.54 which indicates that there is an increase in students' mathematical connection abilities both before and after the use of student worksheets. Improved mathematical connection ability is in the medium category.

The results above, it shows that before and after the use of student worksheets based on guided discovery with a scientific approach has increased. This is because guided discovery-based student worksheets with a scientific approach give students the experience to find concepts independently and actively so that students' abilities increase (Putra, 2018; Mauzana, 2016).

Furthermore, Mulyani & Muhtadi (2019) showed that with the discovery learning, mathematical connection abilities increased in the medium category. This is because in discovery-based student worksheets with a scientific approach students relate mathematical ideas to between topics in mathematics, to other than mathematics, and to everyday life (NCTM, 2000).

The last stage is an evaluation by making improvements to the errors that occurred during the research process.

4. Conclusion

Based on the results of research and discussion, it can be concluded that student worksheets based on guided discovery with a scientific approach were developed using the ADDIE model: (1) student worksheets-based on guided discovery are valid based on validity assessments by experts with a validity score of 4.4 and very good category to improve students' mathematical connection skills; (2) student worksheets-based on guided discovery with a scientific approach meet the practicality criteria with the results of student response questionnaires with a score of 3.16 and are included in the very good category to improve students' mathematical connection skills, and (3) student worksheets-based on guided discovery with an effective scientific approach to improve students' mathematical connection skills with classical completeness by 77% and there is an increase in mathematical connection skills with a value of N-Gain = 0.54 and is included in the medium category. So based on these results it can be concluded that the student worksheets-based on guided discovery with a scientific approach can be used to improve students' mathematical connection skills.

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