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The Development of Mathematical Worksheet based on Surrounding Environment with Problem Based Learning Model to Improve Creative Thinking Ability

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Abstract

This research aims to develop mathematical worksheet product based on surrounding environment in the problem based learning in flat-side space material and to improve creative thinking ability. Using Research and Development with 4D-Thiagarajan model modified 3D (consist of define, design and, develop). The result show that student worksheet is valid, easy to understand, and effective to improve creative thinking ability. The worksheet is valid with an average percentage of 88.60%. Next, the worksheet is easy to understand with a percentage of 83% using a practice tests with a cloze test. Meanwhile, the worksheet can improve creative thinking ability through the paired T-test and right-tailed T-test which was strengthened by the N-gain test with a result of 0.596 on the medium criteria. The worksheet is packaged an atrractive presentation targeting 8th grade and has received e-copyright by Electronic Intellectual Wealth General Directory.

1. Introduction

Mathematics is a universal science that can be said to be the mother of science. His scientific concentration leads to its use with easy to understand language (Hasbullah & Wiratomo, 2015). Mathematics is often considered the most difficult subject by students, because students lack cognitive abilities, lack information, and have difficulty concentrating (Tambychik & Meerah, 2010).

Act of The Republic of Indonesia Number 20, 2003 about national education. To achieve the goals of national education, it is necessary to improve the quality such as of the learning process. The learning process is influenced by several factors such as teachers, learning facilities, learning media, and a conducive school environment (Sumar & Razak, 2016). This is reinforced by Decree of The Indonesian Minister of Education and Culture Number 22, 2016 about the implementation of the student-oriented learning process so that plans are implemented to improve efficiency and effectiveness of competency achievement. In this case, innovative learning is needed as an effort to improve 21st-century skills.

The 21st-century skills are mastery of skills needed to prepare the nation's next-generation for their future careers (Alismail & McGuire, 2015). National Education Association (2012) mentions that 21st-century skills are known as the 4C's, they are critical thinking and problem solving, communication, collaboration, and creativity and innovation. These skills must be fully integrated throughout the school to prepare for everything quality. These 21st-century skills are in line with technological developments that make students continue to innovate to develop relevant skills and competencies (Chalkiadaki, 2018). One of the 4 skills that need to be developed is creative thinking. Creative thinking is perfecting ideas to maximize creative efforts (National Education Association, 2012). This creative thinking ability needs to be developed as a determinant of the nation's superiority because the nation's competitive power depends on the creativity of its resources (Moma, 2015).

The creative thinking ability of students in Indonesia is still said to be in a low category. It is proven from Indonesia's ranking by The Global Creativity Index (GCI) in 2015 was 115 from 139 countries. This

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index is seen from 3T, such as Technology, Talent, and Tolerance (Florida, Mellander & King, 2015). Florida et al, (2015) said that the level of creative thinking can be seen from Creative Class Share (CCS). The ranking of GCI and CCS can be seen in table 1 below.

Table 1. The ranking of GCI and CCS 2015

The Global Creative Index						Creative Class Share		
Rank	**Country**	**Technology**	**Talent**	**Tolerance**	**GCI**	**Rank**	**Country**	**CCS**
1	Australia	7	1	4	0.970	1	Luxembourg	53.68
2	US	4	3	11	0.950	2	Bermuda	47.96
3	New Zealand	7	8	3	0.949	3	Singapore	47.30
⋮						⋮		
115	**Indonesia**	**67**	**108**	**115**	**0.202**	**86**	**Indonesia**	**7.95**
⋮						⋮		
139	Iraq	110	-	130	0.032	93	Guinea	0.75

In addition to GCI and CCS, students' creative thinking abilities based on Programme for International Students Assessment (PISA) are said to below. In the 2018 PISA, Indonesia was ranked 6th out of a total of 78 participants with an average math score of 379 (Schleicher, 2019). PISA questions are considered capable of exploring creative thinking skills, so they can be used as a benchmark for students' abilities (Handayani, Sa'dijah, & Sutanto, 2018).

Table 2. The ranking of PISA Mathematics Competency 2018

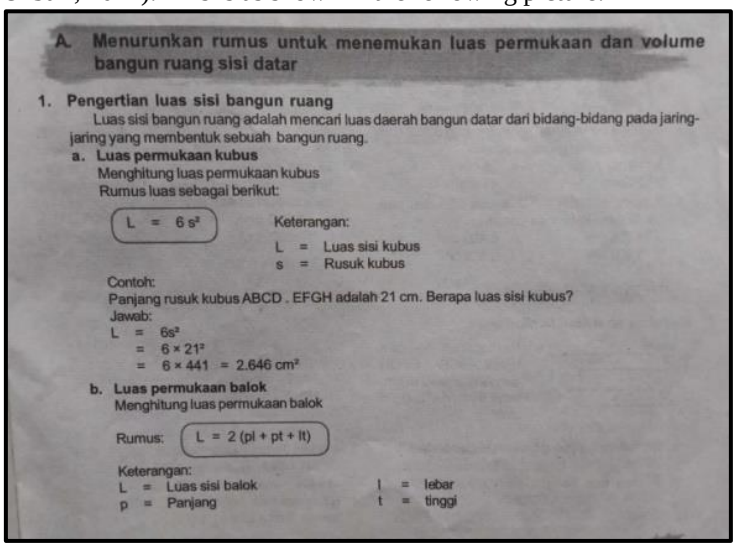
Rank	Country	Mean Score	Level
1	B-S-J-Z (China)	591	Level 4
2	Singapore	569	Level 4
3	Macao (China)	558	Level 4
⋮			
72	**Indonesia**	**379**	**Level 1**
⋮			
78	Dominican Republic	325	Below Level 1

Balitbang Kemendikbud (2019) mentions that level 1 at the level of mathematics competence indicates that students are only able to answer or examine questions that are clearly described (general context) according to the steps given. While the minimum level of competence that must be achieved is level 2 from 6 levels of the PISA test. This explains that the mathematical ability of Indonesian students on average can work on questions that have clear information, such as reading the same table as the redaction of the question. Students have not been able to answer complex questions by working with creative and logical thinking skills as at levels 4, 5, and 6 (Balitbang Kemendikbud, 2019). In addition, learning motivation is also important in creating creative thinking. Low creative thinking ability can be caused by low student motivation to learn. Low motivation also affects students' low interest in learning (Anditiasari et al, 2021).Based on the statement, the creative thinking ability of students in Indonesia needs an improvement.

Puspendik Kemdikbud (2019) stated that the result of the national examination 2018/2019 on the four materials tested was low. Geometry and measurement became the bottom two test materials with the percentage of answering only 42.47%. Meanwhile, seeing from the indicators of the questions tested only two from twelve indicators on the geometry and measurement test material which reached 60% were answered correctly. For example, the indicator for calculating the volume of a flat-side space is only 41.42% form students answering questions correctly. This percentage explains that on average junior high school (JHS) students in Indonesia are still having difficulties with the material for constructing flat-side spaces. Thus learning on this materials needs to be improved.

In the ability to think creatively, it's necessary to have supporting factors, such as a learning process that is appropriate to the needs of students (Abdurrozak & Jayadinata, 2016). Pane & Dasopang (2017) argues that the learning process involves learning components such as tools or media. Examples of learning support tools or media used by many schools are worksheets. However, the worksheets

circulating in schools are generally not made by teachers but from publishers which are less attractive in terms of appearance (Lestari *et al*, 2019). In addition, the worksheet made by the publisher only contains short material and is not presented with a work step guide so that it is like a collection of questions (Astuti & Sari, 2017). This is as shown in the following picture.



A. Menurunkan rumus untuk menemukan luas permukaan dan volume bangun ruang sisi datar

1. **Pengertian luas sisi bangun ruang**
   Luas sisi bangun ruang adalah mencari luas daerah bangun datar dari bidang-bidang pada jaring-jaring yang membentuk sebuah bangun ruang.
   a. **Luas permukaan kubus**
   Menghitung luas permukaan kubus
   Rumus luas sebagai berikut:

   $L = 6s^2$

   Keterangan:
   L = Luas sisi kubus
   s = Rusuk kubus

   Contoh:
   Panjang rusuk kubus ABCD . EFGH adalah 21 cm. Berapa luas sisi kubus?
   Jawab:
   $L = 6s^2$
   $= 6 \times 21^2$
   $= 6 \times 441 = 2.646\ cm^2$

   b. **Luas permukaan balok**
   Menghitung luas permukaan balok

   Rumus: $L = 2(pl + pt + lt)$

   Keterangan:
   L = Luas sisi balok
   p = Panjang
   l = lebar
   t = tinggi

Figure 1. Example of a publisher's worksheet.

Besides not being facilitated by the activity of finding concepts, materials, or discussions in the worksheet made by the publisher has not shown any connection with everyday life (Lestari *et al*, 2019). It can be seen in the questions in the material in figure 1 which refer to practical formulas and are not associated with the surrounding environment. Choiri (2017) States that utilizing the surrounding environment as a source of learning will provide experience to be able to develop self-ability towards things close to oneself. Environmental-based learning can improve creative thinking ability. The results of the research by Neka et al (2015) show that the average gain score of student's creative thinking ability who conduct learning based on the environment is 0.47, which is greater than direct learning that doesn't use an environmental basis, which is 0.34.

Another factor in the learning process that needs to be improved is the learning model used. Hasbullah & Wiratomo (2015) define a learning model as a form of learning that is illustrated from beginning to end as a wrapper or frame of learning approaches, methods, and techniques. A good learning model contains learning oriented to the development of students' knowledge and skills, one of which is problem-based learning (Cahyono, 2017). PBL is a learning model that requires students to be able to construct understanding through the problems given. As research from Abdurrozak & Jayadinata (2016) states that the PBL model is proven to improve students' creative thinking ability and is better than the conventional model based on the results of the statistical test carried out.

Based on the problems that have been described mathematics worksheets need to be developed by linking mathematics to the surrounding environment. This environmental-based worksheet uses PBL model in its application. The purpose of this research is to develop mathematical worksheet product based on surrounding environment in the problem based learning in flat-side space material and to improve creative thinking ability.

2. Methods

This study uses the research and development method (RnD) with the 4D Thiagarajan model which is modified into 3D. Consist of define, design, and develop (Thiagarajan et al, 1974).

The location in this research is SMP N 1 Rembang for two months (July-September). The subjects of this research were validators which included lecturers, mathematics teachers, and 8th class. Researchers designed the research procedures based on the research steps of the development of the modified results of the research and development (RnD) method adapted from Sugiyono (2016:409) combined with a 4D model that was modified into 3D. Consisting of define including potentials and problems as well as data

collections, the design includes product design, the development includes design validation, development, practicality test, and small trial test.

2.1. Define

The define step or definition consists of identifying potential and problems followed by data collection. Potential is something that has added value if used properly (Sugiyono, 2016:409). This potential can be targeted by looking at the existing problems. To find out the potential and problems, observations were made with the aim of (1) knowing the problems faced in learning mathematics including curriculum and field problems; (2) observing the characteristics of students through academic ability, student experience and active learning; (3) analyzing student assignments; (4) analyzing the concept; and (5) specification of learning objectives. The next step after finding the potential and problems from observation, data collection is used such as literature study from various supporting sources.

2.2. Design

The design step serves to design worksheet form draft into a worksheet ready to be used. National Education (in Prastowo, 2015:212-215) states that the preparation steps are divided into four, namely curriculum analysis, compiling a map of worksheet needs, determining the title of a worksheet, and writing a worksheet.

In addition, researchers designed the worksheet consisting of 3 parts namely introduction, content, and closing. The introduction of the worksheet consists of a cover, introduction, table of contents, guidelines for using the worksheet, core competencies, basic competencies, and indicators of basic competency as well as a concept map. The content section of the worksheet includes material descriptions, "mathpedia", "*aku ingin tahu*", "*mari merangkum*" and competency tests. Equipped with student activities, pictures and supporting information, examples, practice questions, and their use. In addition, it is equipped with games such as word search, crossword puzzles, or other fun activities. The final or closing part of this worksheet contains a glossary, bibliography, and author profile. This initial worksheet draft is herein referred to as the draft I worksheet.

2.3. Develop

This stage consists of validating the worksheet design, development, practicality test, and small trial test. This validation is to rate whether the worksheet product is suitable for use in learning.

Validation was carried out by experts consisting of one lecturer and two mathematics teachers at SMP N 1 Rembang. The feasibility questionnaire instrument adapted from the National Education Standards Board includes (1) content feasibility, (2) language feasibility, and (3) presentation feasibility. The questionnaire was compiled with an assessment rubric and a Likert scale from a score of 1-4. Sudijono (2008:43) states that after the validator fills out the questionnaire sheet, the percentage of feasibility is calculated as follows.

$$P = \frac{f}{N} \times 100\%$$

Table. 3 Criteria for level of feasibility

Feasibility Interval	Criteria
$1\% < P \leq 50\%$	Not Feasible
$50\% < P \leq 70\%$	Feasible Enough
$70\% < P \leq 85\%$	Feasible
$85\% < P \leq 100\%$	Very Feasible

(Akbar, 2013:41)

If the percentage score is $\leq 70\%$ will be revised and $> 70\%$ it is worth trying out.

The practicality test was carried out with a cloze test with percentage calculations such as a validity test. Furthermore, the practicality and interpretation will be seen in table 4. If the percentage score is $\leq 40\%$ will be revised and $> 60\%$ stated practical and easy to understand. Then the second draft that has passed the practicality test will become draft III.

Table. 4 Criteria for level of practicality

Practicality Interval	Criteria
$1\% < P \leq 40\%$	Low (difficult for students)
$40\% < P \leq 60\%$	Medium (suitable for students)

$60\% < P \leq 100\%$	High (easy to understand)

(Rankin & Culhane in Niam, 2020)

The small trial test in this study involved five students from 8th grade who were selected based on the domicile closest to the researcher. This test is structured using the One-Group Pretest-Posttest Design as follows.

$$O_1 \times O_2$$

(Sugiyono, 2016)

where,

O_1 : pretest scores before using the worksheet

O_2 : posttest scores after using the worksheet

$O_2 - O_1$: the impact of the worksheet in improving creative thinking skills

The questions before being used for the test were tested for validity, reliability, discriminating power, level of difficulty, normality tests, homogeneity tests. Then it will be seen whether there are differences in creative thinking skills through a paired T-test with the following hypothesis.

H_0 : there is no difference in the average creative thinking ability before and after treatment

H_1 : there is a difference in the average creative thinking ability before and after treatment

The data will be processed using SPSS 21 and interpreted if $Sig. > 0{,}05$ the H_0 is accepted and $Sig. < 0{,}05$ the H_1 is accepted (Muhid, 2019). Then, to find out whether the average posttest value is higher than the average pretest value, a right-tailed T-test was performed. For decision making seen from $Sig. < 0{,}05$ then Ho is accepted. Researchers also want to know how big the difference in creative thinking ability is through the N-gain test with the following formula and interpretation results.

$$\langle g \rangle = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

(Hake, 1999)

Table. 5 The criteria of N-gain

Score $\langle g \rangle$	Criteria
$\langle g \rangle \geq 0.7$	High
$0,3 \leq \langle g \rangle \leq 0.7$	Medium
$\langle g \rangle < 0.3$	Low

(Hake, 1999)

3. Results and Discussions

3.1. Worksheet Development Result

In this study, worksheet products were developed and had gone through a series of stages. The results of each stage are described as follows. Defining at this stage is carried out initial observations directly through interviews and indirectly through literature studies. This is done to find out the problems faced, observe student characteristics, task analysis, concept analysis, and specification of learning objectives.

The results obtained from the problems found are (1) students need a long time in understanding and solve problems, (2) the use of learning models is less than the maximum, for example problem-based learning model, (3) the application of creative thinking skills is lacking and students are still passive, (4) supporting media such as worksheets are rarely used because they are less able to construct understanding, (5) students' reading interest is lacking, and (6) students are not usual to learning independently. Meanwhile, related to potential is the need for changes in learning and maximizing supporting media such as worksheets. This agrees with Astuti & Sari (2017) that maximizing student worksheets can guide students to find something new and make students more independent. Furthermore, data collection is carried out to strengthen the argument through data from schools or other reliable sources. The result is data that supports the making of worksheets.

The design at this stage resulted in a worksheet draft with flat-side space material. This draft was prepared in stages as stated by National Education (in Prastowo, 2015) namely analyzing the curriculum, compiling a map of the worksheet needs, determining the title, and starting writing. The title for the worksheet is "The Worksheet Flat-Side Space material " whose preparation refers to basic competencies 3.9 and 4.9. The initial design for the worksheet consists of 3 parts, namely the introduction, content, and

closing. The introductory section consists of a cover section, a preface, a table of contents, a guide to the use of worksheets, core competencies, basic competencies, and indicators of basic competency as well as a concept map. The introductory part is presented in the following pictures.

(a) (b) (c) (d)

Figure 2. (a) cover; (b) table of contents; (c) usage guide; (d) concept map.

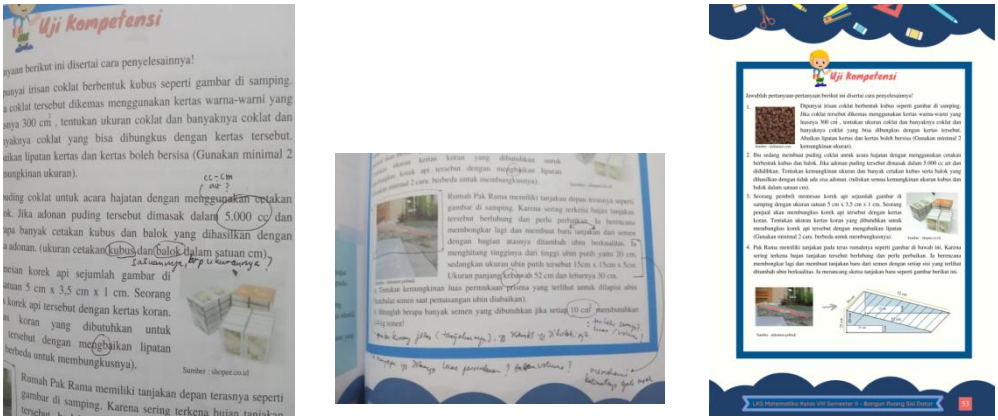
The content section of the worksheet includes material descriptions, mathpedia, "*aku ingin tahu*", "*mari merangkum*", and competency tests. The description of the material does not only contain material on flat-side space material, but also contains various kinds of supports in the discovery of the concept of the flat side. Such as the introduction of spatial shapes through modified spatial shape characters. There are 4 characters, namely "*Si Bubus*","*Si Babal*","*Si Lilim*", dan "*Si Priris*". Supporting icons such as "*Ayo Ingat*", "*Ayo Berpikir Kreatif*", "*Ayo Simpulkan*","*Tahukah Kamu*", and "*Mari Merangkum*". This icon invites students to solve the given problem. The preparation of practice questions in the material description section uses creative thinking indicators. This is done by researchers with the hope that students can grow their creative thinking skills. Other parts that differentiate from the worksheet in general, there are sections "*Aku ingin tahu*" and "Mathpedia. The contents are presented in the following pictures.

(a) (b) (c) (d)

Figure 3. (a) character introduction; (b) material description; (c) mathpedia; (d) "*aku ingin tahu*".

While the closing section consists of a glossary, bibliography, and author's profile. The worksheet draft is then named worksheet draft I to be validated by the validator. The worksheet is designed to include the problem based learning stages to stimulate students to solve problems independently. This is by with Yew & Goh (2016) that problem-based learning begins with problem analysis followed by independent learning which allows students to be actively involved in problem-solving. In addition, the surrounding environment is used to make it easier for students to use the worksheet. This agrees with Hasanah (2014) that the use of the surrounding environment as a learning medium makes it easier for students to apply mathematical concepts to solve daily problems and is more attached to students' memories.

The development at this stage is carried out from the suggestions obtained from the validation results by the validator. These include improving writing and language, size and accuracy of pictures, and developing questions. The worksheet draft I that has gone through this stage becomes the worksheet draft II. The following is a picture of one of the repair parts as follows.



(a) (b) (c)

Figure 4. (a), (b) competency test before repair; (c) competency test after repair.

Furthermore, a small trial test was conducted involving junior high school students who were randomly selected according to the proximity of their domicile. As for the worksheet draft II which has been feasible, then a practicality test and small trial test are carried out to increase students' creative thinking abilities and become the worksheet draft III. The practicality test was carried out with a cloze test totalling 40 questions filled in with 5 students in grade 9. To see the improvement, a pretest and posttest were carried out with the same questions totalling 3 questions in the form of descriptions. After all the stages are passed, the worksheet draft III becomes the final worksheet and is given an e-copyright by Electronic Intellectual Wealth General Directory.

3.2. Feasibility and Practicality Test Results

Feasibility and practicality tests are carried out to obtain appropriate and practical worksheets or easy to understand before being used in learning. The results of the feasibility test are obtained from a feasibility questionnaire that has been filled out by the validator. The validator consists of 1 lecturer and 2 mathematics teachers. The questionnaire is prepared according to the feasibility of the National Education Standards Board including the feasibility of content, language, and presentation.

The average rating of the three validators is 88.60%. Based on the classification of criteria according to Akbar (2013:14) including very feasible criteria. Meanwhile, based on the criteria for each aspect of the assessment, it was found that the feasibility of content was 89.77%, the feasibility of language was 87.82% and the feasibility of presentation was 88.19%. Each aspect of feasibility consists of several sub-aspects and each sub-aspect is further divided into several indicators. Based on the results obtained, the worksheet is feasible to use. The results of the feasibility of each of these aspects are presented as follows.

Table. 6 Feasibility Test Results of Each Aspect

No.	Assessment Aspect	*P*(%)	Criteria
1.	Feasibility of content	89.77	Very Feasible
2.	Feasibility of language	87.82	Very Feasible
3.	Feasibility of presentation	88.19	Very Feasible
	Mean	**88.60**	**Very Feasible**

The practicality test was carried out with a cloze test which consisted of 40 questions. The question was made from taking several parts in the worksheet. The target of this practice test is five randomly selected 9th grade students who have received the material for flat-sided space. The results of the practicality test are an average of 83%. The interpretation of the results according to Rankin & Culhane (in Niam, 2020) is on high criteria and the average number of questions answered correctly is 33 questions. It can be said that the worksheet is stated to be practical and easy to understand. The presentation of the practicality data can be seen in table 7.

Table. 7 Results of The Practicality Test with The Cloze Test

No.	Student Code	Score	Persentage Scor (%)	Criteria
1.	C-01	27	67.5	High
2.	C-02	32	80	High
3.	C-03	35	87.5	High
4.	C-04	32	80	High
5.	C-05	40	100	High
Mean		**33.2**	**83**	**High**

3.3. Small Trial Test Results for Improving Creative Thinking Skills

The usage test in this study was conducted in a limited way by randomly selecting 5 students from 8th grade students of SMP N 1 Rembang based on the students' closest domicile. In this study, each student was taught the material directly using a worksheet with the material on the flat-side space. This is done because the worksheets emphasize the use of direct learning while the school conditions do not allow face-to-face research.

To find out the increase in creative thinking skills, pretest and posttest were carried out with the same questions. The question has previously been tested in other classes to find out the prerequisite test. The results are questions in the valid category, medium reliability, sufficient discriminatory power, easy difficulty level, normal condition and homogeneous. Then the questions used for the test amounted to 3 items of description arranged with creative thinking indicators (fluency, flexibility, and novelty). Furthermore, the results of student answers are calculated according to the paired T-test hypothesis. The result is a value of $0.003 = Sig.(2-tailed) < 0.05$ then Ho is rejected so that there is a difference in the average creative thinking ability before and after treatment. Through the right-tailed T-test, it was found that $0.002 = Sig.(1-tailed) < 0.05$, so Ho was rejected. So that the average posttest is higher than the average pretest. The results of differences in creative thinking abilities can be seen using the N-gain test. The results of the N-gain test calculation are as follows.

Table. 8 N-Gain Test Results

Ideal Score	Mean		N-Gain	Criteria
	Pretest	Posttest		
10	5.3	8.1	0.596	Medium

Based on table 8, the N-gain result is 0.596 which according to Hake (1999) is in the medium category. While the results of the N-gain test for each indicator, it was found that all three were in the medium category. Based on the results of the N-Gain test, it can be seen that there is an increase in creative thinking skills. This is in line with the research of Neka et al (2015) regarding the average N-gain that can be used to see an increase in creative thinking skills before and after being given treatment. The results of the N-gain test for each indicator are presented in the following figure.

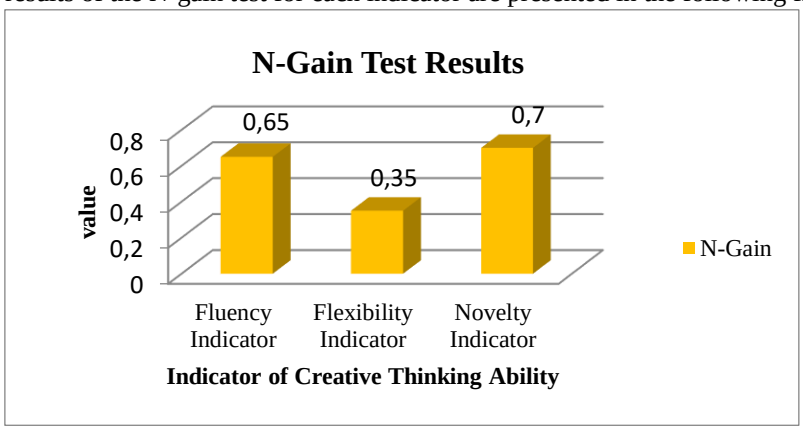


Figure 5. N-Gain Test Result of Indicator.

Furthermore, draft III The worksheets become the product that has gone through a feasibility test, practicality test, and small trial test. The worksheets also received e-copyright by Electronic Intellectual Wealth General Directory. So that the worksheets are suitable for use in learning. In this case, the use of the problem-based learning model combined with the surrounding environment in the worksheet is proven to help improve creative thinking skills. This is supported by research by Nismawati et al (2019) that the combination of using the problem-based learning model with an environmental basis can develop students' thinking skills.

4. Conclusion

Based on the results and discussion, it can be concluded that the development of mathematical worksheet based on environment with problem based learning model to improve creative thinking ability, namely (1) developing worksheets in this study by making changes to worksheets such as applying concept discovery in the content of worksheets, linking with the surrounding environment, applying problem-based learning models in activities and use creative thinking indicators in examples and practice questions, (2) produce feasible and easy-to-understand worksheets with a feasibility percentage of 88.60% and practicality of 83%, and (3) math worksheets based on the surrounding environment on flat-side space material can improve creative thinking abilities. This can be seen from the results of the paired T-test and the right-tailed T-test which show the average difference in creative thinking abilities, reinforced by the N-gain test which is shown to be 0.596 with medium criteria.

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