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# PROCEEDINGS OF THE 7th INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION AND EDUCATION OF MATHEMATICS AND SCIENCES (7th ICRIEMS)


Science, Technology, and Education in The Global Era for Virtuous and Competitive Generation


Yogyakarta, 25 – 26 September 2020

**FMIPA UNIVERSITAS NEGERI YOGYAKARTA**
**INDONESIA**

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**Proceedings of The 7th International Conference On Research, Implementation And Education of Mathematics And Sciences (7th ICRIEMS):** Science, Technology, and Education in The Global Era for Virtuous and Competitive Generation



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# Preface

This proceedings is the regular edition (non-Scopus-indexed) of the conference proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS) held by the Faculty of Mathematics and Science, Yogyakarta State University, Indonesia on 25-26 September 2020 at Yogyakarta State Univesity . All papers in this proceeding were obtained from a selection process by a team of reviewers and had already been presented in the conference. Some selected papers from the conference were compiled under separate proceedings and published by Institute of Physics (IoP) which is Scopus-indexed. This proceedings comprises 9 fields, they are mathematics, mathematics education, physics, physics education, chemistry, chemistry education, biology, biology education, and science education.

The theme of this 7th ICRIEMS is '*Science, Technology, and Education in The Global Era for Virtuous and Competitive Generation*. This conference presented five keynote speakers, which were Martianus Frederic Ezerman, Ph. D (School of Physical and Mathematical, Sciences, NTU, Singapore), Prof. Dwikorita Karnawati, Ph.D (BMKG, Jakarta), Prof . Dr. Gultekin Cakmakci (Hacettepe University, Turkey), Prof. Wing Mui Winnie So (University of Hong Kong), and Dr. Insih Wilujeng (Universitas Negeri Yogyakarta). Besides the keynote speakers, there were also parallel articles that present the latest research results in the field of mathematics, sciences, and education. These parallel session speakers came from researchers from Indonesia and abroad.

Hopefully, this proceeding may contribute in disseminating research results and studies in the field of mathematics, sciences and education such that they are accessible by many people and useful for the development of our civilization.

Yogyakarta, October 2020

Editorial Team

## Forewords From The Head of Committee 2020

Assalamu'alaikum warahmatullahi wabarakatuh
May peace and God's blessings be upon you all

Dear our respected speakers and participants on behalf of the 7th ICRIEMS 2020 Organizing Committee, we would like to extend our warmest welcome to the Yogyakarta.

The 6th International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS) which is organized by Faculty of Mathematics and Science, Universitas Negeri Yogyakarta, Indonesia held today on September, 25-26 2020. The theme of the 7th ICRIEMS is "Integrating Science, Technology, Engineering, & Mathematics (STEM) and Education for Disaster Risk Reduction and Mitigation". We certainly hope that the theme will covers the field of mathematics, chemistry, physics, biology, mathematics education, chemistry education, physics education, biology education, and science education to enhance society knowledge on natural phenomena and geographical position of countries in the ring of fire pathway that have the potential for natural disasters. The knowledge could help people and government agencies to reduce and prevent the emergence of a larger disaster impact.

The conference is an event where prominent practitioners, researchers, students and educators from all around the world are joining together to share their latest research and exchange their ideas. The conference will be a good place to promote or maintain not only national but also international collaboration and networking among academics, researchers and educators. The conference has accepted 210 papers from six countries, i.e. Turkey, Indonesia, Hongkong, Singapore, Malaysia, and Thailand. There are more or less 140 selected papers will be published by AIP Publisher under Scopus Index and Journal of Physics: Conference Series by IOP Publishing also under Scopus Index. The rest of the papers will be published on DOAJ Journals and Regular ICRIEMS Proceeding.

Last but not least, We address very big appreciation and many thanks to all presenters and participants who have been actively involved in this conference. We also wish to thank to our reviewers for invaluable comments and suggestions. We wish you a productive conference and hope you enjoy your time in Yogyakarta and at 6th ICRIEMS 2019!

Wassalamu'alaikum warahmatullahi wabarakatuh.

Yogyakarta, November 2020

Dr. Supardi, M.Si

## Forewords From the Dean of Faculty of Mathematics and Sciences, Universitas Negeri Yogyakarta

May peace and God's blessings be upon you all.

On behalf of the Committee, first of all allow me to extend my warmest greeting and welcome to the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS) 2020, organized by Faculty of Mathematics and Natural Sciences (FMNS) Universitas Negeri Yogyakarta.

The readiness of human resources is required to face up the new era of industrial revolution which demands people to be actively involved in communication system, to think critically, and to have good skills including adaptability, social-emotional learning, growth mindset, and cultural awareness. The challenge for us is getting bigger with the Covid-19 pandemic around the world which changes the order of human life. Mastery and self-readiness are very important to face the world today. This condition could be achieved if it is supported by the empowerment of individuals and scientific and technological innovations in order to adapt to global change which encompasses technological, social, cultural, economic changes and natural events.

With the theme of "Science, Technology, and Education in The Global Era for Virtuous and Competitive Generation", this conference is aimed to pull together researchers, educators, policymakers, and practitioners to share their critical thinking and research outcomes. Therefore, we can understand and examine the development of fundamental principles, knowledge, and technology to adapt to global changes and to prepare the qualified generations. The scope of this conference covers all topics but is not limited to in the field of mathematics, chemistry, physics, biology, mathematics education, chemistry education, physics education, biology education, and science education.

Distinguished guest, ladies, and gentlemen,

This conference will be far from success and we could not accomplish what we do without the support from various parties. So let me extend my deepest gratitude and highest appreciation to all committee members. I would also like to thank each of participants for attending our virtual conference and bringing your expertise to our gathering. Should you find any inconveniences and shortcomings, please accept my sincere apologies.

To conclude, let me wish you a fruitful discussion and an impressive virtual conference.

Yogyakarta, September 2020

Prof. Dr. Ariswan

## PROGRAM OUTLINE

VIRTUAL CONFERENCE PROGRAM
THE 7th INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION & EDUCATION OF MATHEMATICS AND SCIENCES (ICRIEMS) 2020
25-26 September 2020, DIGITAL LIBRARY, UNIVERSITAS NEGERI YOGYAKARTA, INDONESIA
Friday, Sept 25, 2020

| No | Time | Programs |
|---|---|---|
| 1 | 07.30 - 08.00 | Registrasi |
| 2 | 08.00 - 08.30 | Pembukaan |
| | | 1. Menyanyikan Lagu Indonesia Raya |
| | | 2. Laporan oleh Ketua Panitia |
| | | 3. Sambutan dan Pembukaan oleh Rektor UNY |
| 3 | 08.30 - 09.30 | Keynote Speech #1 :<br>Prof. Dr. Lee Ching Kuo<br>(Taipei Medical University, Taiwan)<br>Bidang Kimia |
| 4 | 09.30 - 10.30 | Keynote Speech #2 :<br>Prof. Peter Charles Taylor<br>(Murdorch University Australia, Australia)<br>Bidang IPA |
| 5 | 10.30 - 11.30 | Keynote Speech #3 :<br>Prof. Dr. Suriani Abu Bakar<br>(UPSI, Malaysia)<br>Bidang Fisika |
| 6 | 11.30 - 13.00 | Break |
| 7 | 13.00 - 16.00 | Sesi Paralel I |
| 8 | 16.00 - 16.15 | Penutup |

VIRTUAL CONFERENCE PROGRAM
THE 7th INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION & EDUCATION OF MATHEMATICS AND SCIENCES (ICRIEMS) 2020
25-26 September 2020, DIGITAL LIBRARY, UNIVERSITAS NEGERI YOGYAKARTA, INDONESIA

Saturday, Sept 26, 2020

| No | Time | Programs |
|---|---|---|
| 1 | 08.00 - 08.15 | Pembukaan |
| 2 | 08.15 - 09.15 | Keynote Speech #4<br>Dr. Ariyadi Wijaya<br>(Mathematic, Universitas Negeri Yogyakarta) |
| 3 | 09.15 - 10.15 | Keynote Speech #5:<br>Assoc. Prof. Chatree Faikhamta<br>(Kasetsart University, Thailand)<br>Bidang Kimia/IPA |
| 4 | 10.15 - 11.15 | Keynote Speech #6 :<br>Dr. Agus Purwanto<br>(Institut Teknologi Indonesia)<br>Bidang Fisika |
| 5 | 11.15 - 12.00 | Invited Speakers #1:<br>Assoc. Prof. Vichit Rangpan<br>(Yala Rajabhat University, Thailand)<br>Bidang Biologi |
| 6 | 12.00 - 12.15 | Break |
| 7 | 12.15 - 13.00 | Invited Speakers #2<br>Dr. Retno Arianingrum<br>(Chemistry, Universitas Negeri Yogyakarta) |
| 8 | 13.00 - 16.00 | Sesi Paralel I |
| 9 | 16.00 - 16.15 | Penutup |

**MATHEMATICS EDUCATION (ME)**

# Designing Guided Discovery Learning With a Calculator-Assisted to Learn Trigonometry

**H P Nanmumpuni[1], Jailani[2], and H Retnawati[3]**

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**Abstract**. This paper describes the designs of guided discovery learning with a calculator-assisted for trigonometry, which may be considered a difficult topic for high school students. Trigonometry is one of the topics in mathematics in senior high school that must be studied and has an important effect in the development of students' creative thinking skills, but in reality there are some difficulties experienced by students. An activity "discovery or invention" means an activity or lesson is designed so that students can discover the concepts and principles through his own mental processes. Based on several studies that have been done before, the model of discovery learning is considered able to boost the ability of students' mathematical understanding in mathematics. Learning to use media can make students become more creative, responsible and have their own initiatives in understanding concepts and solving problems without direct teacher assistance. With the development of the times, education seems to shift to a more advanced era. One of them is to use a calculator in learning mathematics. The resulted design may be used in regular mathematics classroom with some adjustment on the difficulty level and the allocated lesson time.

## 1. Introduction

Education is expected to equip students to have the abilities mentioned above in order to be able to support the life of a student. Pasific Policy Research [1] states that the ability to think creatively, flexibly, solve problems, collaborate and be innovative is a skill needed for success in life. Therefore education is expected to be able to develop these abilities. This shows that education is expected to be able to equip students to have the ability to apply the knowledge they have in order to solve problems in daily life, including mathematics education.

Mathematics is the most important part of the development of world science and technology and is one of the subjects studied by students. Mathematics is important for the development of students' mathematical thinking. Based on mathematical material to be studied in school, trigonometry is one part of mathematics that must be studied in senior high school. Trigonometry is a very important subject in mathematics. It is a subject that is taught in schools and a basic concept that are also used in other subjects such as geometric, algebraic and graphical ways of thinking [2].

Trigonometry helps students develop cognitive strategies, such as problem solving through students' reasoning and proving abilities [3]. Problem solving in trigonometry can be considered very difficult for high school students, also for prospective teachers to be mastered [4] and [5]. There are several studies related to analyzing problem solving in trigonometric problems. Teacher should give more opportunities for students to do regular problems, and concentrate to solve problems one step at the time [6].

The students must follow those steps so they can handle the math problems. It is very important to understand, how the students solve their math problems, so the teacher can give some suggestions. Hopefully, in the future they can solve more math problems or even in their daily problems using logic. Most teachers have observed that children have numerous misconceptions about trigonometry. This occurs when teachers discuss proof on trigonometry problem. Trigonometry objects are considered abstract by some student. As a result, students do not believe mathematics, although they acknowledge and understand. Students will also have difficulty in understanding the concepts of trigonometry and students to be passive in learning study results decreased.

In overcoming student difficulties in learning trigonometric material, teachers need to choose innovative learning and be able to help students understand trigonometry based on their direct understanding. One learning model that can be used as an alternative to solve this problem is to use a guided discovery learning model. The guided discovery method departs from the discovery theory developed by Bruner [7] which says that the essence of learning is how people actively choose, maintain and transform. Takdir [8] said discovery is a method that allows students to be directly involved in learning activities so that they are able to use their mental processes to find a concept or theory that is being studied.

In its development, a lot of research was carried out so that the guided discovery learning method emerged prioritizing student activities in finding knowledge through peer guidance and teachers. Eggen & Kauchak say guided discovery is a teaching approach where the teacher provides examples of specific topics and the teacher guides students to understand the topic [9]. An activity "discovery or invention" means an activity or lesson is designed so that students can discover the concepts and principles through his own mental processes. Based on several studies that have been done before, the model of discovery learning is considered able to boost the ability of students' mathematical understanding in mathematics.

Learning to use media can make students become more creative, responsible and have their own initiatives in understanding concepts and solving problems without direct teacher assistance. With the development of the times, education seems to shift to a more advanced era. The development of science and technology has an impact on education, including learning mathematics. One of the results of the development of science and technology that has an impact on learning mathematics is a calculator. The use of technology in mathematics learning can improve the quality of learning [10]. Computers and calculators can potentially shift the paradigm of learning activities from concentrating on manipulative skills to developing concepts, relationships, and problem solving skills.

Teachers have a range of learning strategies and resources available to them to help students develop, consolidate and broaden their understanding of mathematics. Calculators can be used to achieve various mathematics learning objectives. Calculators with appropriate usage strategies can improve student understanding, solve problems, explore concepts and connections through multiple representations, and even develop student understanding. The use of calculators in the upper middle class allows to concentrate more on thinking about problems that require understanding concepts and creative approaches, but this success depends largely on how to use calculators in the classroom and the instructions given by the teacher [11].

The calculator is considered an interactive math dictionary. The main advantage of using a calculator in learning mathematics is that it can process data quickly and accurately. Therefore calculators must be involved in learning mathematics and condition students to explore, observe, study, and make conjectures without doubting their ability to calculate. It is expected that using a calculator in mathematics learning will sharpen thinking skills and analytical skills.

The current article aims to propose designs guided discovery learning with a calculator-assisted for learning trigonometry. In mathematics, trigonometry is a topic that may not be easy to study. Trigonometric

problem solving is the most difficult to understand because it requires a proper understanding of triangles and trigonometric ratios, besides that there is material on trigonometric charts and their shifts.

## 2. Methods

*2.1 The participants.*

The trial subjects were 36 X grade senior high school students in the MIPA group around 15 years old. A student with that age range usually tries to establish interaction and socialize with many people, mainly friends of the same age. A group of students studied trigonometric material through learning using a guided discovery model with a calculator-assisted. Learning is given to students through the implementation of the lesson plan and student worksheets that have been prepared according to guided discovery learning steps assisted by a calculator.

*2.2 The methodology.*

The lesson plan is a teacher's guide in teaching in the classroom. The learning implementation plan is a plan that describes the procedures and organization of learning to achieve a basic competency set out in Standard Content (SI) and described in the syllabus. The preparation of the lesson plan was carried out by studying the Core Competencies (KI) and Basic Competencies (KD) in the 2013 curriculum which was revised according to those used by the school where this research was carried out. Then selected the predetermined subjects, namely trigonometry, formulating indicators, determining learning objectives, compiling lesson plans, consulting with expert judgment and revising the lesson plans that have been consulted, then validated by expert judgment, then revising the lesson plans that have been validated.

Student worksheets are learning aids in the form of a sheet of paper containing information and questions that must be done by students. These student worksheets can be done by students individually or in groups. Student worksheets are a learning aid in the form of sheets of paper containing information and questions that must be answered by students. The arrangement of these student worksheets is in accordance with the components of the guided discovery learning model assisted by a calculator. Student worksheets used in this study were student worksheets designed by the researcher and validated by expert judgment. After being consulted, then revising the worksheets.

The lesson plans and worksheets used in this study are the lesson plans and worksheets designed by researchers and have been consulted with validators or expert judgments. The lesson plans and worksheets have also been shown to teachers in schools. The lesson plans and worksheets are learning tools compiled by the author for use in experimental research he is doing. The trigonometric material for mathematics learning devices for class X SMA Semester II with the help of this calculator can be said to be developed using the Plomp model. The Plomp model [12] has three stages in its development including: (1) preliminary research, (2) the development or prototyping stage, and (3) the assessment stage. The assessment of the quality of the lesson plans and worksheets refers to Nieveen's [13] criteria which include validity and effectiveness.

The data analysis technique for learning tools in the form of lesson plans and worksheets is classified into two, namely qualitative data and quantitative data. The qualitative data that will be used are the results of the validation sheet and the learning observation sheet. As for the quantitative data obtained from the results of the final test of learning. In converting quantitative data into qualitative data using five classifications based on Widoyoko's formula [14], namely as in the table below:

**Table 1.** Classification of Learning Tools

| Interval mean score | Classification |
|---|---|
| $\bar{x} > \bar{X}_t + 1.8sb_i$ | Very good |
| $\bar{X}_t + 0.6sb_i < \bar{x} \leq \bar{X}_t + 1.8sb_i$ | Good |
| $\bar{X}_t - 0.6sb_i < \bar{x} \leq \bar{X}_t + 0.6sb_i$ | Sufficiently |
| $\bar{X}_t - 1.8sb_i < \bar{x} \leq \bar{X}_t - 0.6sb_i$ | Deficient |
| $\bar{x} \leq \bar{X}_t - 1.8sb_i$ | Very deficient |

Note: $\bar{X}_t = \frac{\max score + \min score}{2}$ ; $sb_i = \frac{\max score - \min score}{6}$; $\bar{x}$ : $empiric\ mean\ score$

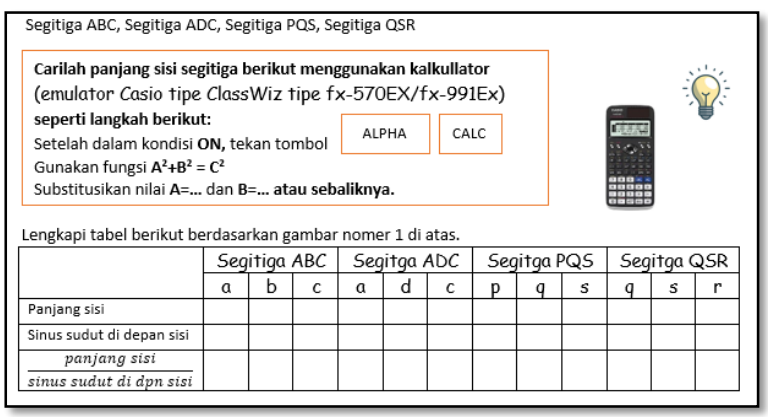
The analysis of the validity of the lesson plans and worksheets learning tools was carried out to determine the validity criteria that were met and previously assessed by the validator using a validation sheet. The learning device can be concluded as valid if the results of the validation by the validator of the enrichment learning device fall within the valid criteria. The learning devices and instruments that will be tested for validity consist of lesson plans, worksheets, and final learning tests. Furthermore, an analysis of the effectiveness of the learning tools is carried out.

When carrying out the effectiveness analysis which aims to determine the extent to which the RPP and guided discovery worksheets assisted by calculators on this trigonometric material meet the effective criteria, it can be determined from the final test results of student learning. The value obtained from the final test is a value of 0-100. This value is compared with the minimum completeness criteria that have been previously set by the school for mathematics, namely 75. Which can be said to be effective if the learning device developed has a percentage of student learning completeness ≥ 75%.

$$the\ completeness\ percentage\ (t)\ = \frac{number\ of\ passed\ student}{number\ of\ student} \text{x } 100\%$$

*2.3 The design of guided discovery learning with a calculator-assisted for learning trigonometry.*

The following is an example of a trigonometric learning design using a guided discovery model with a calculator-assisted in student worksheets.

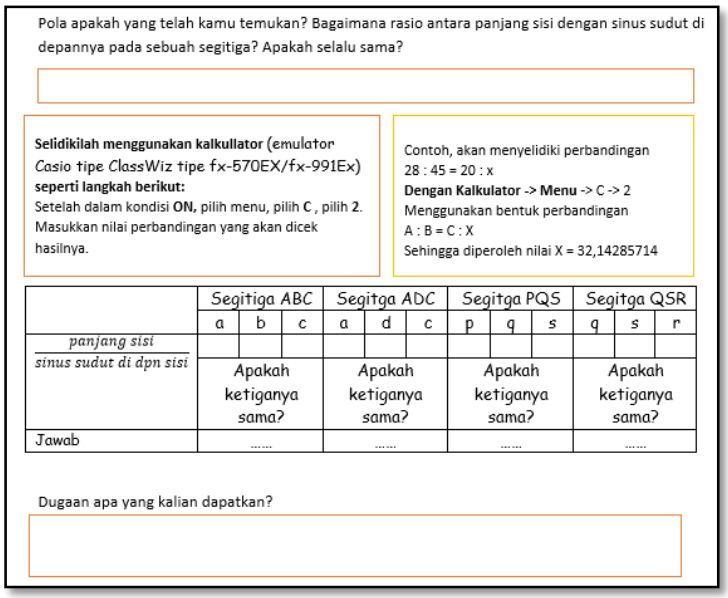

Segitiga ABC, Segitiga ADC, Segitiga PQS, Segitiga QSR

**Carilah panjang sisi segitiga berikut menggunakan kalkullator**
(emulator Casio tipe ClassWiz tipe fx-570EX/fx-991Ex)
**seperti langkah berikut:**
Setelah dalam kondisi **ON,** tekan tombol ALPHA CALC
Gunakan fungsi $A^2+B^2 = C^2$
Substitusikan nilai **A=...** dan **B=... atau sebaliknya.**

Lengkapi tabel berikut berdasarkan gambar nomer 1 di atas.

| | Segitiga ABC | | | Segitga ADC | | | Segitga PQS | | | Segitga QSR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | d | c | p | q | s | q | s | r |
| Panjang sisi | | | | | | | | | | | | |
| Sinus sudut di depan sisi | | | | | | | | | | | | |
| $\frac{panjang\ sisi}{sinus\ sudut\ di\ dpn\ sisi}$ | | | | | | | | | | | | |

**Figure 1**. Utilization of the calculator to calculate.



Pola apakah yang telah kamu temukan? Bagaimana rasio antara panjang sisi dengan sinus sudut di depannya pada sebuah segitiga? Apakah selalu sama?

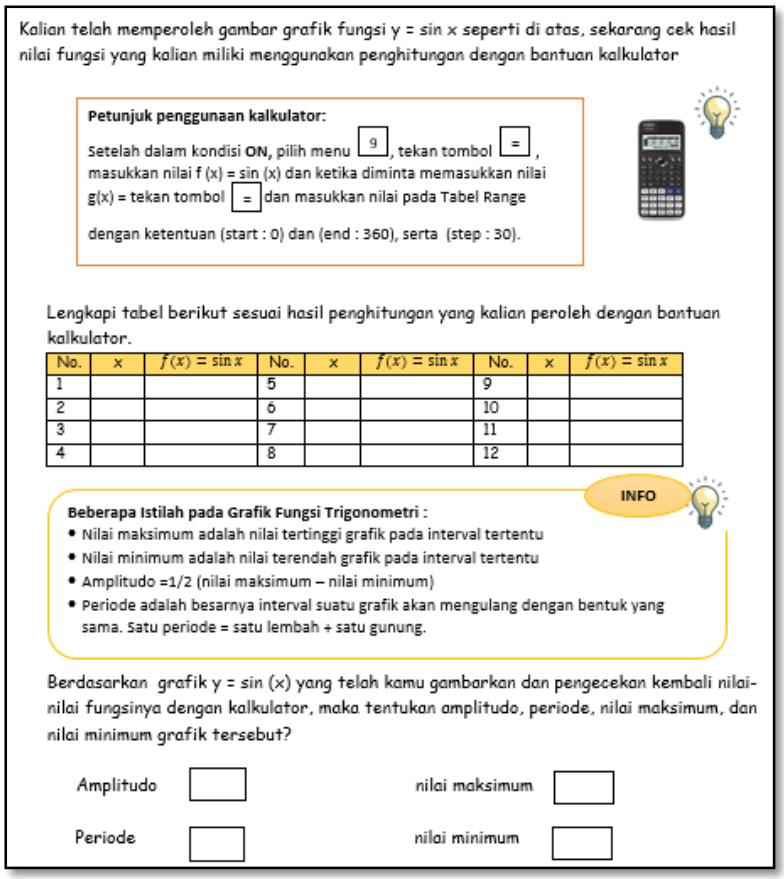
**Selidikilah menggunakan kalkullator** (emulator Casio tipe ClassWiz tipe fx-570EX/fx-991Ex) **seperti langkah berikut:**
Setelah dalam kondisi **ON,** pilih menu, pilih **C** , pilih **2**. Masukkan nilai perbandingan yang akan dicek hasilnya.

Contoh, akan menyelidiki perbandingan
28 : 45 = 20 : x
**Dengan Kalkulator -> Menu** -> C -> 2
Menggunakan bentuk perbandingan
A : B = C : X
Sehingga diperoleh nilai X = 32,14285714

| | Segitiga ABC | | | Segitga ADC | | | Segitga PQS | | | Segitga QSR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | a | d | c | p | q | s | q | s | r |
| *panjang sisi* / *sinus sudut di dpn sisi* | | | | | | | | | | | | |
| | Apakah ketiganya sama? | | | Apakah ketiganya sama? | | | Apakah ketiganya sama? | | | Apakah ketiganya sama? | | |
| Jawab | …… | | | …… | | | …… | | | …… | | |

Dugaan apa yang kalian dapatkan?

**Figure 2**. Use of calculators to carry out investigations or checks.



Kalian telah memperoleh gambar grafik fungsi y = sin x seperti di atas, sekarang cek hasil nilai fungsi yang kalian miliki menggunakan penghitungan dengan bantuan kalkulator

**Petunjuk penggunaan kalkulator:**
Setelah dalam kondisi **ON,** pilih menu [9], tekan tombol [=], masukkan nilai f (x) = sin (x) dan ketika diminta memasukkan nilai g(x) = tekan tombol [=] dan masukkan nilai pada Tabel Range dengan ketentuan (start : 0) dan (end : 360), serta (step : 30).

Lengkapi tabel berikut sesuai hasil penghitungan yang kalian peroleh dengan bantuan kalkulator.

| No. | x | $f(x) = \sin x$ | No. | x | $f(x) = \sin x$ | No. | x | $f(x) = \sin x$ |
|---|---|---|---|---|---|---|---|---|
| 1 | | | 5 | | | 9 | | |
| 2 | | | 6 | | | 10 | | |
| 3 | | | 7 | | | 11 | | |
| 4 | | | 8 | | | 12 | | |

INFO

**Beberapa Istilah pada Grafik Fungsi Trigonometri :**
- Nilai maksimum adalah nilai tertinggi grafik pada interval tertentu
- Nilai minimum adalah nilai terendah grafik pada interval tertentu
- Amplitudo =1/2 (nilai maksimum – nilai minimum)
- Periode adalah besarnya interval suatu grafik akan mengulang dengan bentuk yang sama. Satu periode = satu lembah + satu gunung.

Berdasarkan grafik y = sin (x) yang telah kamu gambarkan dan pengecekan kembali nilai-nilai fungsinya dengan kalkulator, maka tentukan amplitudo, periode, nilai maksimum, dan nilai minimum grafik tersebut?

Amplitudo [ ] nilai maksimum [ ]

Periode [ ] nilai minimum [ ]

**Figure 3**. Make use of a special feature on the calculator to observe patterns.

In Figure 1, it can be seen that the guided discovery learning provided is made use of a calculator as a calculation aid. The calculator function is used to calculate and verify that the three lengths of the triangle

satisfy the Pythagorean theorem. Whereas in Figure 2, the guided discovery learning model provided uses a calculator to carry out investigations or checks. And for Figure 3, the use of special features on the calculator is used to observe the patterns and shifts of the trigonometric graph.

## 3. Result and Discussion

*3.1 Math Learning Tool Product Test Analysis.*

The data analysis process consists of two aspects, namely validity and effectiveness data analysis. The purpose of analyzing this data is to determine the quality of the product being developed and at the same time be in the evaluation phase of the product development process. The data obtained consisted of validity and effectiveness.

The result of the validity of the lesson plan is that the average validation score of the two validators is 119.5 with a good qualitative classification in the range of $98.58 < \bar{x} \leq 121.74$. Therefore, the quality of lesson plans with the help of calculators for guided discovery learning on trigonometric material for class X SMA students is considered valid and feasible. Furthermore, for the student product activity sheet, the validation results obtained were validation scores by two 95 validators with good qualitative classification with a range of $81.6 < \bar{x} \leq 100.8$. Thus, the quality product of the student worksheet assisted by a calculator for class X semester II students is considered valid and feasible.

The final product that is validated is the final test of learning trigonometric material. Based on the score of the validity assessment by the two validators was 48.5 with a good qualitative classification in the range of $44.22 < \bar{x} \leq 54.66$. Therefore, the final test of trigonometry learning with the help of a calculator for class X SMA semester II is considered valid and feasible. The effectiveness of the product of trigonometric learning tools is determined based on the results of learning tests conducted by students. Based on the test results, the percentage of completeness of the final test after enrichment learning was 95.45% with a final test score of 83.72. This figure explains that around 21 of the total 22 students who took the test achieved a PKS score $\geq 75$ and had reached a minimum of 75%. Thus based on these data it can be concluded that the previously developed lesson plan and student worksheets meet the effective classification.

*3.2 The implementation of guided discovery learning with a calculator-assisted for learning trigonometry.*

A number of features in the calculator can strengthen learning mathematics [15]. The use of calculators in upper middle class makes it possible to concentrate more on thinking about problems that require understanding concepts and creative approaches [11].

The use of technology in mathematics learning can improve the quality of learning [10]. Computers and calculators can potentially shift the paradigm of learning activities from concentrating on manipulative skills to developing concepts, relationships, and problem solving skills. The calculator can be viewed as a learning aid.

A calculator according to the electronics dictionary is a special tool for carrying out arithmetic preparations with data and instructions entered into it. Most of these tools require hand intervention, which can be used to carry out logical and digit calculations. The benefits that can be explored from using a calculator are: (1). Helps in understanding mathematical concepts; through experiments using a calculator students can see various relationships between numbers and observe the results on a calculator both numbers and graphs; (2). Help strengthen computational skills strengthening computing skills is usually done through individual or small group activities under teacher guidance; (3). Develop higher-order thinking skills; through the use of a calculator students can explore patterns and make conjectures, while to generalize students can observe and study from many of the many cases displayed calculator. In addition, through calculator learning then students are able to think exploratively through views on calculator; (4). Improve problem solving skills; calculators can be used to overcome general computational harm, so that in solving problem solving problems it allows students to fully concentrate on understanding the contextual

problems and solving procedures freely without feeling hopeless caused by computational difficulties; (5). Make problem solving more realistic; teachers' issues or textbooks usually less realistic. Teacher or book writer usually display the calculation questions as simply as possible not follow natural problems. In everyday life it is often encountered numbers that are not simple, but with the help of a calculator the teacher can provide problems from a more real situation and do not need to hesitate with computational weaknesses.

## 4. Conclusion

Learning trigonometry, especially the rules of sines and cosines as well as trigonometric charts with their changes for students can be facilitated through a guided discovery model with the help of a calculator. Discovery learning can be divided into two, namely free discovery (free discovery) and guided discovery [16]. In practice, guided discovery is more common because with teacher guidance, students will work more directed in an effort to achieve predetermined goals. This teacher-guided discovery model was developed in a lesson which is often called the guided discovery model [17]. This learning can be held individually or in groups. The teacher guides students if necessary and supports students to think for themselves so that they can find general principles based on the material provided by the teacher and to the extent that students depend on the performances and the material being studied.

The use of technology in mathematics learning can improve the quality of learning [10]. The calculator can potentially shift the paradigm of learning activities from concentrating on manipulative skills to developing concepts, relationships, and problem-solving skills. Calculators can be used to achieve various mathematics learning objectives. Calculators with appropriate usage strategies can improve student understanding, solve problems, explore concepts and connections through multiple representations, and even develop student understanding.

The use of calculators in the upper middle class allows to concentrate more on thinking about problems that require understanding concepts and creative approaches, but this success depends largely on how to use calculators in the classroom and the instructions given by the teacher [11]. The calculator is considered an interactive math dictionary. The main advantage of using a calculator in learning mathematics is that it can process data quickly and accurately. Therefore calculators must be involved in learning mathematics and condition students to explore, observe, study, and make conjectures without doubting their ability to calculate.

Therefore, designing learning using a guided discovery model and combining it with the use of a calculator can be used as an alternative for teachers to carry out learning in class, one of which is to learn trigonometry. During the classroom implementation, the teacher may improve the effectiveness by motivating students to study meaningfully. To obtain empirical evidence for the effectiveness of the design, the future investigation is needed such as by comparing this design with the others.

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# Effectiveness of Using Comic to Improve Student Learning Outcomes in Set Operation

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**Abstract**. Some media can be used to help deliver material in class. One of the media that can be used is comics. This study aims to determine the effectiveness of the use of comic learning media to improve the learning outcomes of 7th grade junior high school students on set operation material. Researchers took 3 junior high schools in Lamongan sub-district as samples. This study uses quantitative research with the main objective to determine the effectiveness of the use of comic learning media. This research was conducted by giving a pre-test first, then given treatment that is learning using comic media and post-test. Data analysis was performed by comparing the results of students' pre-test and post-test. The result is an average in student post-test is increase. And calculated by using statistics method, so that it can be concluded that the use of comic learning media is effective in improving student learning outcomes on set operation.

## 1. Introduction

One of the materials taught at the beginning of learning for junior high school students is the set. The set is very important to be taught to students because the set is the basis of all Mathematical sciences. By studying the set, it is hoped that the ability of logic will be more honed and will spur someone to be able to think logically. Logic has an important role because it is related to reason. Meanwhile, at this time training in reasoning, problem solving, communication, and connection skills in mathematics still did not fill the standards[1][2].

Most students are accustomed to doing learning activities by paying attention to the teacher's explanation, duplicating it, and then memorizing it. To overcome this problem, researchers are convinced that efforts should be made to develop joyful learning media in accordance with the development of junior high school students. Learning media are defined as physical means, in addition to teachers, blackboards and textbooks, through learning that is presented to students [3]. The most productive role for the media is as a computational and memory device to eliminate unproductive cognitive tasks that can interfere with the construction of knowledge by students [4]. The purpose of multimedia teaching messages is to encourage meaningful learning [5]. Other instructional media such as audio visuals do not replace teachers but must be carefully integrated with lessons and continuously evaluated to strengthen the learning process [6]. Content in the media must be designed by experts who are competent in certain subjects, and it is not a requirement for them to become experts in the technology field. After the content has been designed, the electronic version will be developed by the content developer [7].

An educator especially a mathematics teacher must have a way of presenting material that makes it easy and makes students eager to follow learning. One of them is to familiarize mathematics with

students' daily lives[8]. One of the teaching aids that can be used to support students' interest in slow learning in learning is comics [9]. Based on this introduction, the purpose of this study is to determine the effectiveness of the use of comic learning media on set operation materials. Comic help students improve their reading skills and discuss science issues. In addition, comics can also motivate students to think about science and research [10]. In the process of teaching and learning activity, comic helps teacher or educator to teach and present the material, especially in mathematics learning [8][11]. For example, comics used in teaching algebra and geometry. Based on studies conducted by Toh (2008), students find it helpful to have comics [12]. This was also conveyed by the teachers who stated that the images contained in the comics helped students understand algebraic symbols. Studies conducted by Liu (2004), show that students who are at a low level have increased grades when receiving material using comics [13]. In this research, comics are used as a medium to see whether a student can go beyond the level to move up a grade or not. Whereas in this study, comic learning media was used to see student learning outcomes at the same level.

In this study, researchers wanted to find out whether the use of comic learning media was effective to improve junior high school student learning outcomes on set operation material.

## 2. Method

### *2.1. Research Objective*

The research question for this research is whether the comic learning media is effective in improving student learning outcomes in the set operation material. This research uses quantitative research in the form of a one-group pre-test and post-test. Based on these research questions the following research hypotheses can be taken.

$H_0$ = Comic learning media is not effective in improving student learning outcomes in the set operation material.

$H_1$ = Comic learning media is effective in improving student learning outcomes in the set operation material.

### *2.2. Sample*

The sample of this study was taken from 3 junior high schools in Lamongan District of grade 7th, with details of 90 students. All of students from 3 schools are recomended from mathematics teacher in their schools. The mathematics teacher gives reasearcher the learning outcome. The student's ability based on learning outcome data are same.

### *2.3. Research Tools and Procedure*

#### *2.3.1 Research Instrument*

The instrument used is in the form of comic learning media. Comic learning media contains an explanation of the concept of set operation material presented with a display resembling a comic strip. The characters in the comics explain in detail the concept of set operations. There are two characters (as sibling) who play a role in this comic. In this content, we just take two character because we want to make deeper in character soul. The background of this comic learning media is the zoo because the subject of this research are junior high school students that have adventure soul, so the reader will be invited to learn the material of the set operation using the examples of animals.

On the next strip, the two characters' conversations will be displayed about the example set, not the set, the universal set, the set operation (complement, difference, union, intersection). In this comic, there are two girls who visit the zoo. In discussing the set operation material, the two figures illustrate the set operation material with the animals in the zoo. Here are a few examples of comics.


**Figure 1.** Ilustration of set concept in comic

*2.3.2 Research Procedure*

The research procedure was carried out in two stages (there is one meeting during the research), namely the first meeting with the provision of a pre-test (previously students received the set operation with conventional learning) and the second meeting using comic learning media, then given a post-test in the same day. Before the comic learning media is carried out, students are first given a pre-test regarding set operations. It aims to determine the ability of students about the set operation material. Students are asked to do a pre-test for 30 minutes.

After that proceed with learning to use comics. This learning is carried out during a mathematics learning meeting. When learning with comic media, students access comics on their mobile phones for one hour. Students are expected to understand the concept of set operations. After students learn the concept of set operations through comics. Students are given a post-test for 30 minutes to check the extent of students' understanding of set operations in the same day. The pre-test and post-test are equivalent because the two tests aim to find out the extent of students' abilities in the material of set operations.

*2.4 Data Analysis*

The data analysis technique was carried out to analyze the collected data so as to get conclusions from the research results. The data analysis conducted to test the effect of the use of comic learning media to the students in set operation by using paired sample t-test in SPSS 17.0 ,in this case the sample used only one group. This analysis aims to determine the difference between the pre-test and post-test given to the research sample.

## 3. Result and Discussion

*3.1. Result Discussion*

The main objective of this study is to determine the effectiveness of using comic learning media to improve the learning outcomes of 7th grade high school students on set operation material. In this research an analysis conducted using quantitative statistics SPSS 17.0 by comparing the average obtained at pre-test and post-test, obtained the following data.

**Table 1.** The Average of Pre-test and Post-test

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 40.4444 | 90 | 17.76318 | 1.87240 |
| | posttest | 68.3333 | 90 | 19.47340 | 2.05268 |

In Table 1, it appears that there is an increase in the average from pre-test to post-test. This means students have increased learning outcomes. Based on calculations using SPSS 17.0, we get Table 1, the results of the pre-test and post-test on 90 students, it can be seen that the average pre-test result is 40.4444 and the average post-test result is 68.3333. So that there was an increase in the average student learning outcomes after being given comic learning media, namely 27.88889. To answer the research hypotheses that have been submitted, quantitative statistical calculations are performed, which are as follows.

Statistically it can be written as follows

$H_0$ = Comic learning media is not effective in improving student learning outcomes in the set operation material.

$H_1$ = Comic learning media is effective in improving student learning outcomes in the set operation material.

Statistically it can be written as follows

$H_0 = \mu_{PRE} = \mu_{POST}$

$H_1 = \mu_{PRE} < \mu_{POST}$ (*)

**Table 2.** Paired Samples T-Test Statistics calculation

| | | Paired Differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | t | df | Sig. (2-tailed) |
| Pair 1 | pretest - posttest | -27.888 | 10.6786 | 1.1256 | -30.125 | -25.652 | -24.77 | 89 | .000 |

Based on Table 2, the t-count is $-24.776$ and $sig(2-tailed)$ 0.000 with $\alpha = 0.05$, it can be seen that the value t-count $<$ 0 and the value of $\frac{1}{2}sig(2-tailed) < \alpha$, so it uses the left side test and $H_0$ is rejected. So $H_1$ is accepted. So it is proven that the comic learning media is effective in improving student learning outcomes in the set operation. So that the use of instructional media in mathematics can provide significant results and is effective enough to improve students' arithmetic skills on set operation. The use of learning media provided by the teacher will give a different learning impression for students in participating in learning activities[6]. So that the existence of comic media learning media will be able to increase student interest in learning. With the use of comic learning media, students can construct their own knowledge by reading comics about set operations given by the teacher. In addition, with the use of these comics students will not be bored in taking mathematics lessons. This study assessed the effectiveness of comic learning media as a learning aid to improve student learning outcomes. Data shows that the use of comic media is

successful and in line with the proposition that the cartoon material available in comics is a valuable tool that encourages student learning outcomes [14]. Learning by using comics as a medium can improve student performance, improve student learning outcomes, and get positive responses from students. This is also in line with other studies that show that there are positive cognitive effects of cartoons.That statement was also reinforced by Setiyani's opinion that comic media is in accordance with student learning because it can improve students' understanding ability and student interest in learning[15].

Based on the results of this study, student learning outcomes when not treated with learning media were still low, but when treated with comic learning media, student learning outcomes increased. So,we found evidence that using comics as a learning aid can support indicators that can improve student learning outcomes that are still low, students are eager to learn, tendencies of attention in learning, willingness to be involved in the learning process, and active participation in learning. The use of comics as teaching and learning tools is very useful in the classroom. Comics as a way to encourage students who are reluctant to be interested and follow what is usually given to them in traditional text-based packages, then comics can also increase the active participation of students in the learning process [14]. Combining text with visual representation when teaching students contributes to increasing student attention, participation, and student interest in learning. Students enjoy learning with comics because this is a new experience for them. To enhance critical thinking skills and accomodate the junior high school students' character was needed the learning media, like comic, which well-design and properly fit the character of junior high school students. It should integrate in the teaching materials such that enabling students to learn actively, collaborative, and fun and also appropriate to the stages of their mental do the mathematics[16]. Based on these reviews, it appears that the use of comics is effective in improving student learning outcomes in the set operation material[8].

## 4. Conclusion

Based on the discussion above, the conclusion of this study is the use of comics as an effective learning medium to improve the learning outcomes of junior high school students in the Lamongan sub-district on the subject of set operations. This is indicated by an increase in student learning outcomes after using comic learning media. Comics can be used as a medium to encourage increased student learning outcomes. It also aims to make students not only learn from the usual textbooks.

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# Students' Worksheet Validity Based on Ethnomathematics with STEM Approach for Junior High School Student

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**Abstract**. This research is motivated by the importance of cultivating cultural values that began to disappear in the era of the industrial revolution 4.0. One alternative solution to this problem is to create mathematics teaching materials in the form of student worksheets that can instill cultural values but still train students' knowledge, skills, and understanding to solve problems in daily life. Thus, it is necessary to develop ethnomathematics-based student worksheets with the STEM (*Science, Technology, Engineering, & Mathematics*) approach. Therefore, this research aims to determine the validity of ethnomathematics-based student worksheets using the STEM approach for junior high school students on a material two-dimensional and three-dimensional geometric figures. This development research uses a 4-D development model that consists of the stages of define, design, develop, and disseminate. The results of the validity test show that the average aspects of display, content, and language are 4.75 with very valid criteria, 3.9 with valid criteria, and 3.92 with valid criteria, respectively. Meanwhile, the overall validation results showed an average of 4.19 with valid criteria. In addition to meeting the validity criteria, the ethnomathematics-based student worksheet with the STEM approach met the eligibility criteria reaching 81.85% with excellent quality.

## 1. Introduction

Mathematics is a science that is widely applied to every aspect of life. It is a challenge for teachers to make updates in mathematics education through the development of mathematics learning systems that are relevant to daily life. Students are more pleased with learning mathematics visually, contextually, and doing direct practice rather than learning mathematics theoretically and abstractly [1]. Therefore, teachers need to provide opportunities for students to master the knowledge, skills, and understanding that can equip them to have the ability to solve problems in daily life. This ability can be obtained through mathematics learning integrated into the STEM (*Science, Technology, Engineering, & Mathematics*) approach.

Currently, STEM is an important issue in the world of education in Indonesia. STEM is a learning approach that integrates two or more disciplines of science between science, technology, engineering, and mathematics with one or more subjects [2]. So, STEM can be used as an approach to learning. The STEM approach invites students to think comprehensively with problem-solving patterns that aim to teach students to think critically and have the creativity and innovative solutions to solve problems in daily life. STEM can train students' abilities, including 1) be able to design, develop, and utilize technology; 2) able to hone cognitive, manipulative, and affective abilities; and 3) able to apply knowledge [3]. The results of previous researches show that the application of STEM can create

meaningful and concrete learning [4], effectively used in the learning process and the achievement of learning objectives [5], prepares students to develop the skills needed in 21st-century education [2], and improve creative thinking skills [6]. So, this approach is suitable to be applied in mathematics learning.

In mathematics, there is the term ethnomathematics. Ethnomathematics is a science that integrates mathematics with cultural values in learning mathematics [7]. Besides, ethnomathematics is defined as mathematical concepts and techniques developed in different cultures to solve problems in daily life [1]. Ethnomathematics is a process to find out how different cultural groups understand, articulate, apply concepts, and practice in mathematics [8]. So, it can be concluded that ethnomathematics is a science that represents mathematical concepts that are relevant to the socio-cultural context for solving problems in daily life. In Indonesia, it is known to have a variety of cultures so that each culture has a different way to solve the problem at hand. Therefore, mathematics and culture are two interrelated things. Mathematics can be extracted from culture, while culture provides a significant influence on the learning process, especially mathematics learning. It is because culture can affect the mindset, language, behavior, and manners that are applied in the learning process. Different cultures develop different or unique ways to count, discover, measure, draw, represent, play, and explain students' needs and interests [9]. It causes a culture to determine the way students look at responding to a condition, especially in understanding the material and mathematical problems. Ethnomathematics can help students to be able to recognize and understand mathematics concretely in the context of culture, especially Indonesian culture. Therefore, ethnomathematics is a science that helps teachers and students understand the influence of culture on mathematics and how this influence results in various ways of using and communicating mathematics [10]. Ethnomathematics objects can be in the form of historical heritage objects (artifacts) or crafts, games, or traditional food from culture. Thus, ethnomathematics can be an alternative planting of noble cultural values that began to disappear in the era of the industrial revolution 4.0.

In the era of the industrial revolution 4.0 in the 21st-century, with the rapid development of technology, students must have thinking skills that include logical thinking skills, analysts, critical, and creative. It means that students are the main players in facing the challenges of the industrial revolution 4.0. Therefore, students are expected to develop thinking skills so that learning outcomes increase optimally. However, the use of technology has created an imbalance between education and life. The use of technology makes all information easily accessible. Thus, students become less friendly with the surrounding environment. Therefore, it is necessary to have a forum that can bridge the cultivation of cultural values in students but does not leave students' creativity and critical thinking skills. It means it requires a relationship between various forms of science, including communication, language, culture, religion, art, science, technology, engineering, and mathematics, that can facilitate education in the 21st-century [9]. One of them is developing teaching materials in the form of ethnomathematics-based student worksheets with the STEM approach.

In this research, the development of ethnomathematics-based student worksheets with the STEM approach is a worksheet that contains simple project-based student learning activities using cultural concepts. The simple project contained in the worksheets developed in this research is an instructional method that includes questions, challenging phenomena that involve problem-solving skills using simple equipment, internet, and computer technology. The material used is junior high school mathematics, which includes two-dimensional and three-dimensional geometric figures. Through ethnomathematics, students learn to see cultural elements that exist around them and in Indonesia that are related to two-dimensional and three-dimensional geometric figures. Whereas through STEM, students learn how to work with project-based methods. In previous researches, there has been no research on the development of ethnomathematics-based student worksheets using the STEM approach. Based on this, and there is a theory that reveals that ethnomathematics has a close relationship with the STEM approach [9], researchers are interested in developing student worksheets by combining two learning approaches. There is an important role in the application of ethnomathematics and STEM in learning are: 1) mathematics learning is more relevant to the culture around students; 2) students can practice the ability to accept and adapt to new technology; 3) train to work in groups; 4) train how to

communicate complex ideas to group members; and 5) train to find creative and critical solutions to solve the problems at hand [9]. This approach allows students to view culture not only from a mathematical side but also from the science, technology, or engineering side [11]. Therefore, the purpose of this research was to determine the feasibility of validity for the preparation of ethnomathematics-based student worksheet components using the STEM approach.

## 2. Method

This research is a type of Research & Development. The product developed in this research was in the form of ethnomathematics-based Student Worksheets with the STEM approach for junior high school students. The development model used in this research refers to the 4-D development model. The 4-D development model consists of four stages is to define, design, develop, and disseminate. The instrument used in this research was a validation sheet. Data collection techniques used in this research used the interview method and the validation sheet research. The interview is used to conduct a needs analysis related to the concept of student worksheets that will be developed. Meanwhile, review the validation sheet used by the validator to assess the appropriateness of the results of the student's initial worksheet design.

In this research, the researcher focused on the validation process in three aspects: display, content, and language. These three aspects are important components in developing student worksheets. In the display aspect, it aims to assess whether the appearance of the student worksheet looks attractive and is by the ethnomathematics concept. Meanwhile, in the content aspect, it aims to evaluate whether the material used on student worksheets is by the ethnomathematics concept with the STEM approach. In the language aspect, it aims to assess whether the content of the student worksheets uses language that is communicative and easily understood by students. The validators in this research were two mathematics education lecturers with a minimum of postgraduate education and one practitioner who was a mathematics teacher in junior high school with a minimum of undergraduate education. After validation, the researcher makes revisions according to the suggestions and criticisms were given by experts and practitioners until a final student worksheet is obtained. Then, the final draft of the student worksheet was tested on a small group are six students in the 9th-grade of MTs Hasyim Asy'ari Lamongan as a readability test. The readability test aims to see whether the student worksheet can be read clearly and easily understood by students. The trial was carried out on 9th-grade students because they had received the material being tested. After that, the data from the results of the validator's assessment were analyzed descriptively quantitatively.

Analysis of data on the validity of ethnomathematics-based student worksheets using the STEM approach aims to assess whether the student worksheets prepared to meet the validity criteria. The qualitative data obtained were then converted into quantitative data by recapitulating the validity score based on the Likert scale, as shown in Table 1.

**Table 1.** Likert scale interpretation

| Score | Criteria |
|---|---|
| 5 | Excellent |
| 4 | good |
| 3 | Moderately good |
| 2 | Slightly good |
| 1 | Not good |

Furthermore, calculate the average validation results from all validators in each aspect and calculate the total average. Based on the total average, it refers to the interval of determining the validity criteria of student worksheets, as in Table 2.

**Table 2.** The formula for student worksheets validity criteria

| Interval | Criteria |
|---|---|
| $\bar{x}^{a} > \bar{E}_i^{b} + 1.8\, Sb_i^{c}$ | Very Valid |
| $\bar{E}_i + 0.6\, Sb_i < \bar{x} \leq \bar{E}_i + 1.8\, Sb_i$ | Valid |
| $\bar{E}_i - 0.6\, Sb_i < \bar{x} \leq \bar{E}_i + 0.6\, Sb_i$ | Quite Valid |
| $\bar{E}_i - 1.8\, Sb_i < \bar{x} \leq \bar{E}_i - 0.6\, Sb_i$ | Less Valid |
| $\bar{x} \leq \bar{E}_i - 1.8\, Sb_i$ | Invalid |

[a] Total Average
[b] Ideal Score Average = $\frac{1}{2}(Ideal\ Maximum\ Score^{d} + Ideal\ Minimum\ Score^{e})$
[c] Ideal Standard Deviation = $\frac{1}{6}(Ideal\ Maximum\ Score - Ideal\ Minimum\ Score)$
[d] Highest score on the Likert scale
[e] Lowest score on the Likert scale

Then, researchers make conclusions about the validity of the student worksheets. Student worksheets are said to be valid if they are at valid or very valid criteria. In addition to obtaining the total average as validity data, the percentage of student worksheet quality criteria will also be obtained as eligibility data, as shown in Table 3.

**Table 3.** Percentage of student worksheet quality criteria

| Interval (P%) | Criteria |
|---|---|
| $\mathbf{0} \leq \boldsymbol{P}\% < \mathbf{2}0$ | Not Good |
| $20 \leq \boldsymbol{P}\% < 40$ | Slightly Good |
| $40 \leq \boldsymbol{P}\% < 60$ | Moderately Good |
| $60 \leq \boldsymbol{P}\% < 80$ | Good |
| $80 \leq \boldsymbol{P}\% \leq 100$ | Excellent |

## 3. Results and Discussion

The following are the results and discussion of research regarding the validity of the ethnomathematics-based student worksheet with the STEM approach for junior high school students based on the validity test.

### *3.1. Results*

In this research, the feasibility of validating student worksheets in terms of three aspects consists of aspects of display, content, and language. After the ethnomathematics-based student worksheet with the STEM approach goes through a validation process by three validators consisting of two lecturers and one math teacher, then the validation results are recapitulated and analyzed. The recapitulation of the results of the student worksheet validation, as shown in Table 4.

**Table 4.** Recapitulation of the ethnomathematics-based student worksheet with the STEM approach results

| No | Indicator | Validator | | | Average | Criteria |
|---|---|---|---|---|---|---|
| | | A | B | C | | |
| | Display Aspect | | | | | |
| 1 | The cover design is appropriate for the concept and material of the student worksheet. | 5 | 5 | 5 | 5 | |

| No | Indicator | Validator | | | Average | Criteria |
|---|---|---|---|---|---|---|
| | | A | B | C | | |
| 2 | Display attractive student worksheet layouts. | 5 | 5 | 5 | 5 | |
| 3 | The type and size of the font are appropriate for the writing layout. | 5 | 5 | 5 | 5 | |
| 4 | The format of the student worksheets is arranged coherently. | 4 | 4 | 5 | 4 | |
| Display Aspect Total Score | | 19 | 19 | 19 | 19 | |
| Display Aspect Average | | 4.75 | 4.75 | 4.75 | 4.75 | Very Valid |
| Content Aspect | | | | | | |
| 5 | The title of the student worksheet is appropriate for the concept and material. | 5 | 5 | 5 | 5 | |
| 6 | The learning objectives are clearly written. | 4 | 4 | 5 | 4.33 | |
| 7 | The writing for instructions on doing practice questions is clear. | 4 | 5 | 5 | 4.67 | |
| 8 | The delivery of the concept of two-dimensional and three-dimensional shapes is precise. | 3 | 4 | 4 | 3.67 | |
| 9 | The content of the material is appropriate for the learning objectives. | 4 | 3 | 3 | 3.33 | |
| 10 | Practice questions have various levels of difficulty. | 3 | 3 | 3 | 3 | |
| 11 | The suitability of the difficulty level of the question exercises on the student worksheets with the level of student cognitive development. | 4 | 4 | 4 | 4 | |
| 12 | Student worksheets help to improve students' critical thinking skills. | 3 | 4 | 4 | 3.67 | |
| 13 | The content of the material is appropriate for the ethnomathematics concept. | 4 | 4 | 4 | 4 | |
| 14 | The ethnomathematics concept is appropriate for the STEM approach. | 3 | 3 | 4 | 3.33 | |
| Content Aspect Total Score | | 37 | 39 | 41 | 39 | |
| Content Aspect Average | | 3.7 | 3.9 | 4.1 | 3.9 | Valid |
| Language Aspect | | | | | | |
| 15 | The use of writing rules is appropriate for the enhanced spelling system. | 4 | 4 | 5 | 4,33 | |
| 16 | The use of language is communicative, interactive, and straightforward by students. | 4 | 3 | 4 | 3,67 | |
| 17 | Use language that is easy to understand. | 4 | 4 | 4 | 4 | |
| 18 | Use of unambiguous sentences. | 3 | 4 | 4 | 4,67 | |
| Language Aspect Total Score | | 15 | 15 | 17 | 15,67 | |
| Language Aspect Average | | 3.75 | 3.75 | 4.25 | 3.92 | Valid |

Based on Table 4, it is obtained the average validity of student worksheets based on ethnomathematics with the STEM approach for each aspect, which then refers to the validity criteria of student worksheets in Table 5. The criteria for the validity of the student worksheets were derived based on the formula in Table 2. The results showed that the display aspect obtained an average of 4.75 with very valid criteria. Meanwhile, in the content aspect, an average of 3.9 with valid criteria was obtained. And, in the language aspect, an average of 3.92 was obtained with valid criteria.

**Table 5.** Student worksheet validity criteria.

| Interval | Criteria |
|---|---|
| $\bar{x} > 4.2$ | Very Valid |
| $3{,}4 < \bar{x} \leq 4.2$ | Valid |
| $2.6 < \bar{x} \leq 3.4$ | Quite Valid |
| $1.8 \leq 2.6$ | Less Valid |
| $\bar{x} \leq 1.8$ | Invalid |

After obtaining the average validity of student worksheets for each aspect, it is necessary to look at the validity of student worksheets as a whole. The average score of the total validity results was 4.19 with valid criteria, as shown in Table 6

**Table 6.** The average score of the validation results in all aspects

| No | Indicator | Validator | | | Average | Criteria |
|---|---|---|---|---|---|---|
| | | A | B | C | | |
| 1 | Display Aspect | 4.75 | 4.75 | 4.75 | 4.75 | Very Valid |
| 2 | Content Aspect | 3.7 | 3.9 | 4.1 | 3.9 | Valid |
| 3 | Language Aspect | 3.75 | 3.75 | 4.25 | 3.92 | Valid |
| Total Score | | 12.2 | 12.4 | 13.1 | 12.57 | |
| Total Average ($\bar{x}$) | | 4.07 | 4.13 | 4.37 | 4.19 | Valid |

In addition to meeting the validity criteria, ethnomathematics-based worksheets with the STEM approach also meet the eligibility criteria. The eligibility criteria for student worksheets with excellent quality reached a percentage of 81.85%, as shown in Table 7.

**Table 7**. Student worksheet quality criteria

| No | Indicator | Validator | | | Average | Criteria |
|---|---|---|---|---|---|---|
| | | A | B | C | | |
| 1 | Display Aspect | 19 | 19 | 19 | 19 | |
| 2 | Content Aspect | 37 | 39 | 41 | 39 | |
| 3 | Language Aspect | 15 | 15 | 17 | 15.67 | |
| Total Score | | 71 | 73 | 77 | 73.67 | |
| Percentage of Validation Results (P%) | | 78.89 | 81.11 | 85.56 | 81.85 | Excellent |

So, it can be concluded that the ethnomathematics-based student worksheet with the STEM approach is declared valid for every aspect and as a whole and is suitable for use as student teaching materials with excellent quality. The results of the validation of the student worksheets were used as the basis for revision to produce the final draft of the student worksheets before testing in large groups.

### *3.2. Discussion*

The results of the validation analysis show that the ethnomathematics-based student worksheet with the STEM approach for junior high school students is declared valid in every aspect and as a whole with excellent quality criteria. In the display aspect, the use of colors, the selection of images, and the type

of font are the supporting factors for the cover design and the layout of the student worksheets to be exciting and appropriate for the predetermined concept. The display of an attractive student worksheet design has a motivation function [12], so that it can make students have high motivation to learn. The average acquisition of 4.75 makes the content display included in the very valid criteria. The ethnomathematics-based student worksheet cover display with the STEM approach is shown in Figure 1.

In addition to the display aspect, the validators pay special attention to the content aspect because it is the most important part and is prone to errors in developing student worksheets. In the content aspect, the average score is 3.9, which is included in the valid criteria. Valid in the content aspect shows that the material selection is by the ethnomathematics concept with the STEM approach. The purpose of combining the two approaches is to train students' critical thinking skills and skills in solving problems in everyday life. Based on the theory in previous research, STEM-based ethnomathematics can foster creative, critical, and reflective thinking through project-based learning with an understanding of the context, perceptions, ideas, and ideas developed by members of different student cultural groups [9]. Students can build their knowledge to find concepts and the teacher is only a facilitator. An example of the contents of an ethnomathematics-based student worksheet with the STEM approach is shown in Figure 2.

In the language aspect, the language criteria are the eligibility requirements for student worksheets that must be considered in terms of writing and language selection. The choice of language and vocabulary in the preparation of student worksheets must be adjusted to the habits and level of thinking of students. The use of language that is adapted to the habits and level of thinking of students will make it easier for students to understand the contents of the messages conveyed on the material developed on student worksheets [12]. The average acquisition of 3.92 makes language aspects included in the valid criteria.

Overall, ethnomathematics-based student worksheets with the STEM approach obtained an average of 4.19 included in the valid criteria with the eligibility percentage reaching 81.85% with excellent quality criteria. Therefore, ethnomathematics-based student worksheets with the STEM approach are declared valid and fit for use.


**Figure 1.** Ethnomathematics-based student worksheet cover with the STEM approach

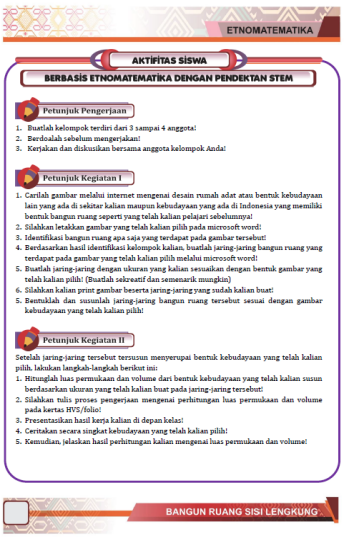


**Figure 2.** Student activities on ethnomathematics-based student worksheets with the STEM approach

## 4. Conclusion

The validity of the development of ethnomathematics-based student worksheets with STEM approach in terms of display, content, and language aspects respectively obtained an average of 4.75 with very valid criteria, 3.9 with valid criteria, and 3.92 with valid criteria. Also, the total average reaches 4.19 with valid criteria, and the percentage of eligibility reaches 81.85% with excellent quality criteria. Thus, ethnomathematics-based student worksheets with the STEM approach are declared valid and fit for use. This student worksheet can be used for 9th-grade students who have received material about two-dimensional and three-dimensional geometric figures.


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# The Validity of Student Worksheet Circle Material Based on Realistic Mathematics Approach to Practice Mathematical Problem Solving Ability of Junior High School Students

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**Abstract.** This research aims to develop and produce a valid student worksheet circle material based on a realistic mathematics approach for junior high school students. This research was a research development that adapts the Plomp development model which consists of three stages, the initial research stage, the prototype making stage, and the assessment stage. The subject of this research was the student worksheet circle material based on a realistic mathematics approach. The instruments of collecting data in this research was validity questionnaires from material experts, media experts, and linguists. This study concludes that the results of the validity of the worksheet circle material based on realistic mathematics approach was valid according to the material experts (81.25%), media experts (86.25%), and linguists (70%). The average validity of material, media and language aspects were 79.16% which means good and then student worksheet could be used for limited trial.

## 1. Introduction

The curriculum in Indonesia emphasized the importance of problem solving, reasoning, communication, and appreciating the usefulness of mathematics as a goal of learning mathematics in elementary, junior high school, senior high school, and vocational schools [1]. The purpose of learning mathematics in Indonesian curriculum was in line with the purpose of learning mathematics according to National Council of Teacher of Mathematics (NCTM) [2]. NCTM recommended five standards process in teaching and learning, 1) problem solving, 2) reasoning and proof, 3) connections, 4) communication, and 5) representation [3]. From these competencies, problem solving was considered as the heart of mathematics learning[4]. Because it was hoped by mastering problem solving ability, students could apply it to solve problems not only in mathematics but also in daily life. The importance of problem solving ability was also expressed by Surya (2017) who said that mathematical problem solving ability could equip students to think logical, analytical, systematic, critical, and creative [5].

Because of the importance of problem-solving abilities that had been described, researchers were interested in developing and producing student worksheet that could practice students' mathematical problem solving abilities. Student worksheet is a printed teaching material that contains material,

summary, and instructions for implementing learning tasks that must be done by students so that they can learn independently [6]. According to Suyitno, student worksheet was one of the learning alternatives appropriate for students because student worksheet helped students to add information about concepts learned through systematic learning activities [7]. This student worksheet developed was expected to be able to facilitate students with a variety of non-routine questions, especially high order thinking questions to train the students' mathematical problem solving ability.

There were several approaches that could be used in learning mathematics. One of them was a realistic mathematical approach. Realistic mathematical approach was first developed in the Netherlands, precisely at the Freudenthal Institute, Utrecht University, since the 1970s [8]. Realistic mathematical approach was first introduced by Hans Freudenthal, a mathematician from the Netherlands, who stated that mathematics was human activity [9]. Researchers chose a realistic mathematical approach as the basis for preparing student worksheet that would be developed because realistic mathematical approach had several characteristics, 1) Learning process begins with contextual problems, 2) Using vertical instruments in the form of models, schemes, diagrams or symbols as a bridge between informal procedures in a formal form, 3) Students actively construct their mathematical material problem solving strategies with teacher guidance, 4) Students were allowed to convey ideas, negotiate explicitly, collaborate, and evaluate among students, learning tools, and constructive interaction between students and teachers, 5) Different topics could be integrated to bring out an understanding of a concept simultaneously[10]. In line with the statement of Gravemeijer (1995), Van den Heuvel-Panhuizen and Drijvers (2020) said that the characteristic of realistic mathematical approach was that rich, “realistic” situations were given a prominent position in the learning process. Such situations serve as a basis for initiating the learning of mathematical principles, methods and procedures and as a background in which students could apply their mathematical knowledge at a later level [11].

Student worksheet as a learning development product must meet validity, practicality, and effectiveness criteria [12]. Valid or not learning devices were based on two things, content validity and construct validity. Content validity referred to suitability development of learning tools with models development used. In this research content validity was known from the suitability of development learning tools with a development model Plomp. Meanwhile, construct validity referred to suitability of the relationship between components, meaning each learning devices related to one another. In this study the construction validity was determined from the results of the assessment of learning tools through validation sheet filling done by the validator. The validity of the construction could be fulfilled when the assessment results from the validator to the learning device developed categorized as valid or very valid. Learning media including student worksheet said to be practical if it could be used easily. This level of convenience depended on the assessment of the validator. The validators stated that the learning device can be used with revision or without revision. Learning device developed was said to be effective if in accordance with that expected, namely increasing the students' mathematical problem solving abilities

Based on the description above, it was necessary to develop student worksheet circle material based on realistic mathematics approach to practice mathematical problem solving ability of junior high school. The purpose of this study was to describe validity of student worksheet based on validation of experts.

## 2. Methods

This research is development research. Development research aims to produce learning tools, such as syllabus, teaching materials, media, practicum modules, student worksheets, measuring tools learning progress, tools to measure learning outcomes [13]. This research aims to develop and produce a valid student worksheet circle material based on a realistic mathematics approach for junior high school students. This research question is whether the student worksheet developed and produced meets the valid criteria and suitable for use limited trials. The subject of this research was the student worksheet circle material based on a realistic mathematics approach.

The developed student worksheet contains six sub topics, (1) elements of a circle, (2) value of phi ($\pi$) and the circumference of the circle, (3) the area of the circle, (4) the relationship between the center angle and the perimeter angle facing the same arc, (5) the perimeter angle facing the same diameter and arc, (6) the relationship of the center angle to the arc length and area of the radius. The developed student worksheet follows the learning steps according to the realistic mathematics approach. The developed student begin with (1) presenting a problem, (2) asking students to understand the problem, (3) explaining the problem faced, (4) solving contextual problems, (5) comparing or discussing answers, then (6) concluding. Display of student worksheets can be seen in Figure 1.

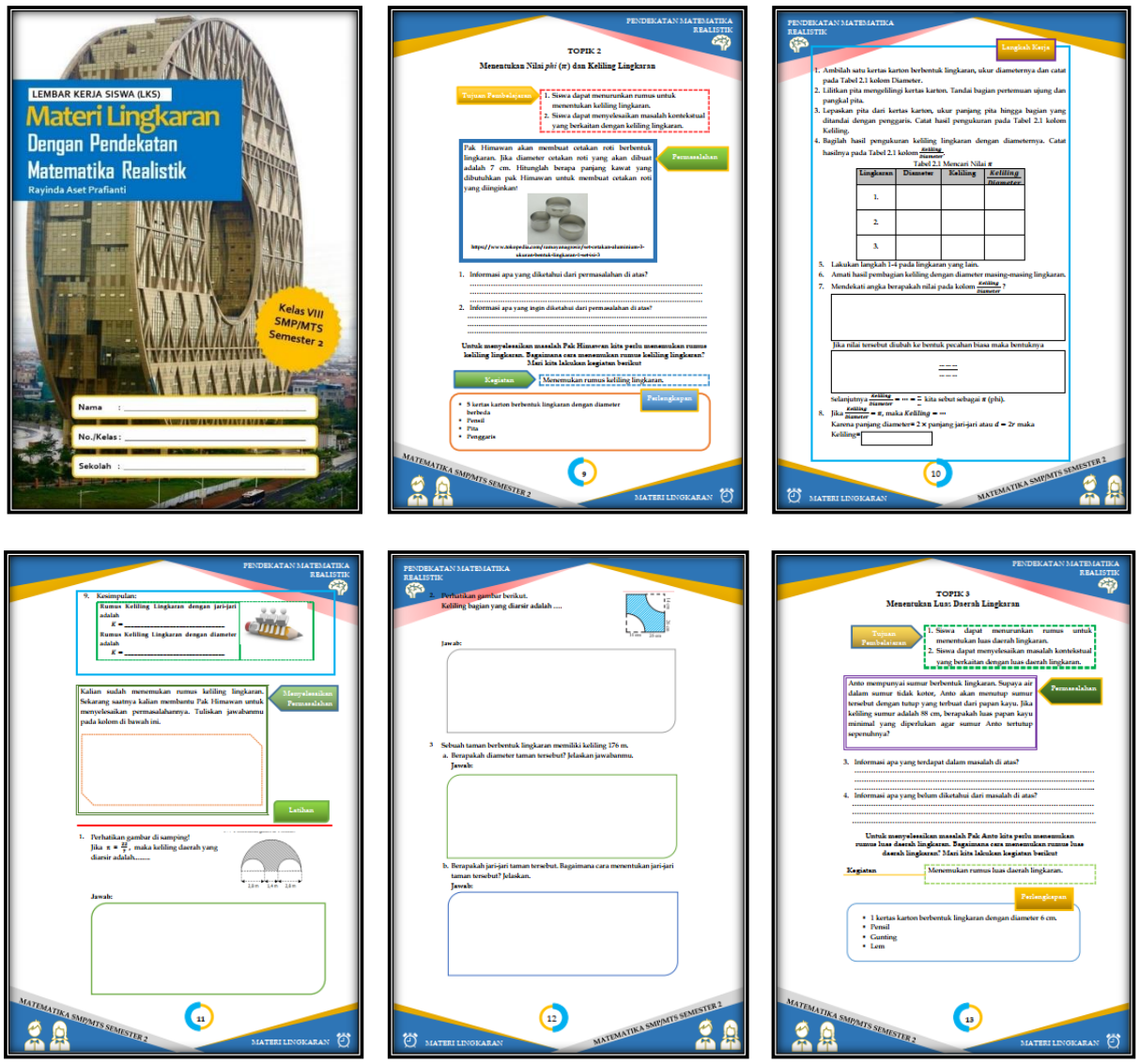


**Figure 1.** Display of Student Worksheet

The student worksheet developed also contain practice questions to practice mathematical problem solving abilities of students. There are two types question in the student worksheet developed, essay questions and multiple choice questions as shown in Figure 2.

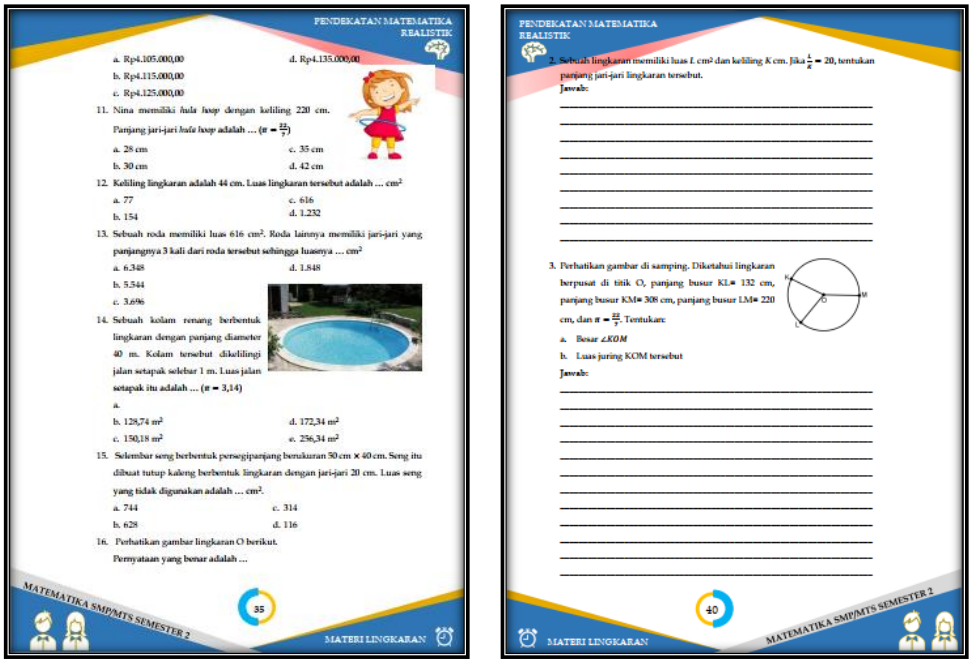


**Figure 2**. The Display of Practice Questions in The Student Worksheet Developed

The research and development model used in this study adapted the Tjeered Plomp development model which consisted of three stages: the initial research stage, the prototype making stage, and the assessment stage [14]. In the initial research phase, two activities were carried out, field surveys and literature reviews. A field survey was conducted to conduct a needs analysis. In the prototype making stage, students drafted worksheets and realize the draft. In the assessment stage, validation of student worksheet was carried out by validators, revision of student worksheet, and limited trials.

However, this article only reviews the assessment stage, which was the validation stage of the student worksheet that had been compiled at the prototype making stage. The validation process was carried out by two material experts, two media experts, and two linguists. Each validator was an expert in their field. Research instruments at the evaluation stage were the student worksheet validation sheet by the material experts, student worksheet validation sheet by the media experts, and the student worksheet validation sheet by the linguist. Data collection method used was the validation method. The assessment used a Likert scale of 1-5 as shown in Table 1.

**Table 1.** Likert Scale Interpretation.

| Likert Description | Likert Scale |
|---|---|
| Not good | 1 |
| Slightly good | 2 |
| Moderately good | 3 |
| Mostly good | 4 |
| Completely good | 5 |

Source: [15]

Data from the results of the validator's assessment were analyzed in a quantitative descriptive way, which was to illustrate and describe the assessment following the assessment indicators by percentage. Furthermore, the data will be converted in the form of a percentage with formula (1).

$$P(\%) = \frac{Score\ each\ criterion}{Maximum\ score\ for\ each\ criterion} \times 100\% \quad (1)$$

From the calculation using formula (1), the results were obtained in the form of a percentage which was then interpreted into categories in Table 2. Student worksheet was said to be valid if the results of the assessment were in mostly good or completely good criteria.

**Tabel 2.** Likert Scale Distribution of Values.

| Percentage (%) | Category |
|---|---|
| 0 – 20 | Not good |
| 21 – 40 | Slightly good |
| 41 – 60 | Moderately good |
| 61 -80 | Mostly good |
| 81 - 100 | Completely good |

Source: [15]

## 3. Research Results and Discussion

The results of the validation of student worksheet are used as a basis for revision so that a good student worksheet is obtained before a limited trial is conducted. Table3, Table 4, and Table 5 show the results of validation from material experts, media experts, and linguists.

**Table 3.** Student Worksheet Validation Value by Material Expert.

| No. | Assessment Aspects | Rating Score V-1 | Rating Score V-2 | P(%) | Criteria |
|---|---|---|---|---|---|
| | **Format** | | | | |
| 1. | Clarity of instructions for doing the exercises | 5 | 5 | 100 | Completely good |
| 2. | Variety of examples and practice questions in student worksheet | 4 | 4 | 80 | Mostly good |
| 3. | The suitability of the material, examples, and practice questions in the worksheet | 4 | 5 | 90 | Completely good |
| 4. | Appropriate appearance of images and writing on the worksheet | 5 | 4 | 60 | Moderately good |
| | **Content** | | | | |
| 1. | Suitability of circle material with material in student worksheet | 4 | 5 | 90 | Completely good |
| 2. | Clarity of the concept of the circle presented at the student worksheet | 3 | 4 | 70 | Mostly good |
| 3. | The material contained in the worksheet is in accordance with the learning objectives to be achieved | 4 | 4 | 80 | Mostly good |
| 4. | Suitability of the level of difficulty in the practice of worksheet with the level of cognitive development of students. | 4 | 4 | 80 | Mostly good |
| | **Total** | 31 | 34 | 81,25 | Completely good |

**Tabel 4.** Student Worksheet Validation Value by Media Expert.

| No. | Assessment Aspects | Rating Score V-1 | Rating Score V-2 | P(%) | Criteria |
|---|---|---|---|---|---|
| | **Format** | | | | |
| 1. | Clarity of instructions for using student worksheet | 3 | 5 | 80 | Mostly good |
| 2. | Appropriate type, size and layout of letters | 4 | 4 | 80 | Mostly good |
| 3. | Suitability of the image with the material | 4 | 5 | 90 | Completely good |
| 4. | Color matching of each page | 5 | 4 | 90 | Completely good |
| | **Content** | | | | |
| 1. | Integration of sequences between pages | 4 | 5 | 90 | Completely good |
| 2. | The image used is interesting | 4 | 5 | 90 | Completely good |
| 3. | The beauty of the student worksheet layout design | 3 | 5 | 80 | Mostly good |
| 4. | The suitability of the material, examples, and practice questions with indicators | 4 | 5 | 90 | Completely good |
| | **Total** | 31 | 38 | 86,25 | Completely good |

**Tabel 5.** Student Worksheet Validation Value by Linguists.

| No. | Assessment Aspects | Rating Score V-1 | Rating Score V-2 | P(%) | Criteria |
|---|---|---|---|---|---|
| | **Language** | | | | |
| 1. | Use good and correct Indonesian grammar | 5 | 5 | 100 | Completely good |
| 2. | The effectiveness of the sentences used | 4 | 5 | 90 | Completely good |
| 3. | The language used is easily understood by students | 5 | 4 | 90 | Completely good |
| 4. | Spelling accuracy | 5 | 5 | 100 | Completely good |
| | **Total** | 14 | 14 | 70 | Mostly good |

Table 3 showed that the student worksheet include valid criteria with a validity value of 81.25%. Table 4 showed that the student worksheet include valid criteria with a validity value of 86.25%. Table 5 showed that the student worksheet include valid criteria with a validity value of 70%. Table 3, Table 4, and Table 5 showed that the student worksheet developed had qualified the requirements for preparing student worksheet according to the Ministry of National Education, namely didactic requirements, construction requirements, and technical requirements [16].

Didactic requirements in compiling student worksheet paid attention to the principles of effective learning. The use of worksheet in learning activities was more emphasized on the process of finding a concept, so that the worksheet function as instructions for students to seek knowledge, and could be used by all students, whether high-ability, moderate, or low [16]. Based on Table 3, it was known that there were two assessment criteria which was reviewed from the didactic requirements, namely the material in the student worksheet in accordance with the learning objectives to be achieved and the suitability of the difficulty level of the question exercises on the student worksheet with the level of student cognitive development. Validity value of each assessment item was 80% with the mostly good category. This matter showed that the student worksheet developed in accordance with didactic requirements and it could be used by all ranges high, medium, and low level of student thinking.

Technical requirements in developing student worksheet were related with the appearance of student worksheet [16]. Based on Table 4, it was known that 1) the beauty of the student worksheet layout design with a validity value of 80% with the mostly good category, 2) the suitability of the images with the material with a validity value of 90% with the completely good category, 3) the color match of each

page with a validity value of 90% with the completely good category, and 4) the images used interesting with a validity value of 90% with the completely good category.

Construction requirements in the preparation of student worksheet relate to language use, sentence structure, simplicity, and the use of words that could understood by students [16]. Based on Table 5, it was known that there were four assessment criteria in terms of construction requirements, 1) the use of good and correct Indonesian grammar with a validity value of 100% in the completely good category, 2) the effectiveness of the sentences used with a validity value of 90% with the completely category good, 3) the language used was easy to understand by the students with a validity value of 90% with the completely good category, and 4) spelling accuracy with a validity value of 100% with the completely good category.

## 4. Conclusion

The validity of the material aspect is 81.25%, it means very good. The validity of the media aspect is 86.25%, it means very good. The validity of the language aspect is 70%, it means good. The average validity of material, media and language aspects are (81.25% + 86.25% + 70%): 3 = 79.16% it means student worksheet developed is in the good category. Student worksheets have met the requirements for developing student worksheets, namely didactic requirements, construction requirements, and technical requirements. Based on the assessment, student worksheet circle material based on realistic mathematics approach is said to be valid and can be used for limited trials.

## 5. Suggestion

This research was only tested on a limited basis, so that further research is needed to know the effectiveness of learning with use student developed worksheets. We recommend on subsequent research, paying more attention to allocations the time provided for working on student worksheets as well pay attention to the clarity of the material needed for activities in student worksheets so that a series of learning activities can done well and maximally.

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# The Outcomes of Mathematical Proficiency Study

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**Abstract.** There are five components of *mathematical proficiency* which needed to be possessed by students so it can be said as a success in learning mathematics. These components divided into *conceptual understanding*, *procedural fluency*, *strategic competence*, *adaptive reasoning* and *productive disposition*. The data collecting method that used in this study is descriptive method through content analysis research type. The analysis result in this study will be discussed about what the conceptual understanding, procedural, fluency, strategic competence, adaptive reasoning and productive disposition are intended to, also some of the result concerned on the fifth components in student's mathematical proficiency in Indonesia. This study then obtained that students in Indonesia generally still have not achieved their mathematical ability yet.

## 1. Introduction

Student needs some matters to be successful in learning mathematics [1]. One of the efficacy-maker in learning mathematics is through mathematical proficiency. The mathematical proficiency by [2] is consisted of (1) conceptual understanding; (2) procedural fluency; (3) strategic competence; (4) adaptive reasoning and (5) productive disposition. It is also in line with [3] about the standards of mathematical subjects stating that the mathematics as a subject is aimed for students to: (1) possess mathematical knowledge (included concept, the inter-link of concept and algorithm); (2) use reasoning/logical; (3) solve the problem; (4) communicate ideas with symbols, tables, diagrams or other media to clarify circumstances or problems and (5) have an attitude to appreciate the usefulness of mathematics. [2] argued that mathematical proficiency is not something which apart, which means that it cannot be accomplished with merely focusing on one component itself. Similar to [4] that mathematical proficiency is not a separated domain, those five are interacted to reinforce one's knowledge, skills, abilities and beliefs. The education in mathematics should prepare students to deal with the changing circumstances and mindsets in life and also preparing them to use mathematical mindsets in everyday life [5]. Therefore, it is important to direct the mathematical learning so that the thinking skill can be trained mathematically. One way that can be done is through the development of the five components mentioned before.

Stated that all students can possess mathematical proficiency [6], the changes in mathematics learning, teaching materials, assessment, the teacher's education and also the education system must be made, specifically: (1) the learning must be able to develop all components of mathematical proficiency; (2) the teaching material used must be integrated with those components; (3) the assessments conducted on students must contribute to the goal of mathematical proficiency; (4) the teacher must possess skill that enable them in teaching so that they have the mathematical proficiency; and (5) the efforts to achieve mathematical proficiency for all students, must be done in a coordinated, comprehensive, and scientifically informed. In connection with the achievement of mathematical proficiency by students, NRC mentioned that this cannot be achieved individually by themselves which means that the parties which has interest (parents, teachers and policymakers) must cooperate to improve the students' mathematical proficiency.

This study is in order to describe about those five mathematical proficiency, such as *conceptual understanding*, *procedural fluency*, *strategic competence*, *adaptive reasoning*, and

*productive disposition*, also describe how the result toward the students in Indonesia are, regarding those components of the mathematical proficiency This article will focus on what is meant by each of five components and how the result work toward students in Indonesia regarding those five components of mathematical proficiency.

## 2. Research Methods

In this study, the data collecting method used is a descriptive one with the type of content analysis research. The results of this article will discuss about what is meant by conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition, as well as some of the results regarding to those five components.

Systematic literature review is used by referring to the following steps : (1) identifying research question, (2) developing research protocols, (3) determining the database location of research result, (4) selecting appropriate research results, (5) choosing good quality research, (6) extracting the selected research results, (7) synthesizing results, and (8) presenting results.

### *2.1 Research question*

The aim of this study is to describe mathematical proficiency in general also each of five aspects included in the proficiency.

### *2.2 Data collection*

*2.2.1. Database searched.* Searching for research papers by online database journals : http://garuda.ristekdikti.go.id/, Google Scholar, Mendeley, focusing on the subject of mathematical proficiency.

*2.2.2. Search keyword.* The keyword used in the search for research papers on the online database are “mathematical proficiency” and “the results towards Indonesian’s students by putting those proficiency

*2.2.3. Selection of papers.* Selected papers for further review must meet the following criteria : (1) learning outcomes, (2) paper published in the 2000-2018 range, and (3) research subjects are mathematical proficiency, how the result toward students in Indonesia regarding those five components of mathematical proficiency, conceptual understanding, procedural, fluency, strategic competence, adaptive reasoning and productive disposition.

### *2.3 Data analysis*

*2.3.1. Extraction of selected papers.* There are 15 selected papers that meet the criteria in 2.2.3. It is extracted by observing the following data: author, year of publication, research subject, variable, and geographic origin of data.

*2.3.2. Synthesis of results.* The synthesis of the results was carried out by looking at the extraction results at 2.3.1. the data we grouped based on mathematical proficiency and its five aspects, also a mathematical proficiency used in senior high schools.

## 3. Result and Discussion

Table 1 below shows the results of searching for papers related to keywords as specified in 2.2.2. and meet the criteria for selecting papers set out in 2.2.3., the totals are 15 paper.

**Table 1.** Appropriate search results papers.

| No | Author (years of publication) | Subject | Variable | Geographic origin of data |
|---|---|---|---|---|
| 1 | Widjajanti, D. B. (2011) | Mengembangkan Kecakapan Matematis Mahasiswa Calon Guru Matematika Melalui Strategi Perkuliahan Kolaboratif Berbasis Masalah | Mathematical Proficiency | Indonesia |
| 2 | Soebagyo, J. (2012) | Profil Pembelajaran dalam Mengakomodasi Mathematical Proficiency | Mathematical Proficiency | Indonesia |
| 3 | Damayanti, W.N., Mayangsari, N.S., & Mahardhika, T.L. (2017) | Analisis Kesalahan Siswa dalam Pemahaman Konsep Operasi Hitung pada Pecahan. | Conceptual Understanding | Indonesia |
| 4 | Sarlina. (2015) | Miskonsepsi Siswa Terhadap Pemahaman Konsep Matematika pada Pokok Bahasan Persamaan Kuadrat Siswa Kelas X5 SMA Negeri 11 Makassar | Conceptual Understanding | Indonesia |
| 5 | Badjeber, R. & Mailili, W. H. (2018) | Analisis Pengetahuan Prosedural Siswa SMP pada Materi Sistem Persamaan Linear Dua Variabel Ditinjau dari Gaya Kognitif | Procedural Knowledge | Indonesia |
| 6 | Kurnadi & Safitri, P. T. (2018) | Peningkatan Kemampuan Kompetensi Strategis Matematis Siswa Melalui Model Pembelajaran Kuantum | The ability of Strategical and Mathematical Competence | Indonesia |
| 7 | Ozdemir, I. E. Y. & Pape, S. J. (2012) | Supporting Students' Startegic Competence : A Case od a Sixth-Grade Mathematics Classroom | Students' Strategic Competence | Turkey |
| 8 | Turner, R. (2010) | Identifying Cognitive Processes Important to Mathematics Learning but Often Overlooked. In Teaching Mathematics Make it Count : What Research Tells Us About Effective Teaching and Learning of Mathematics | Cognitive Processes | Australia |
| 9 | Suhendra, D., Sugiatno & Suratman, D. (2016) | Potensi Penalaran Adaptif Matematis Siswa Dalam Materi Persamaan Garis Lurus di Sekolah Menengah Pertama | Mathematical Adaptive Reasoning | Indonesia |

| | | | | |
|---|---|---|---|---|
| 10 | Putra, Y, W, Rizki dan Sari Linda. (2016) | Pembelajaran matematika dengan Metode Accelerated Learning untuk Meningkatkan Kemampuan Penalaran Adaptif | Adaptive Reasoning Competence | Indonesia |
| 11 | Hidayati, F. & Susanah. (2017) | Profil Penalaran Adaptif Siswa dalam Memecahkan Masalah Open Ended ditinjau dari Kemampuan Matematika | Adaptive Reasoning Competence | Indonesia |
| 12 | Randolph, A., Philipp & John, M. (2015) | Studying Productive Disposition : The Early Development of A Construct. | Productive Disposition | California |
| 13 | Kurniasari, I. (2013) | Identifikasi Kesalahan Siswa dalam Menyelesaikan Soal Geometri Materi Dimensi Tiga Kelas XI IPA SMA | Conceptual Understanding | Indonesia |
| 14 | Syukriani, Andi. (2016) | Kompetensi Strategis Siswa SMA Berkemampuan Matematika Tinggi dalam Menyelesaikan Masalah Matematika | Students' Strategic Competence | Indonesia |
| 15 | Zakaria, E., Nordin, N.M. (2007) | The effects of mathematics anxiety on matriculation students as related to motivation and achievement | Students' Strategic Competence | Indonesia |

From the variables above, it can be seen that lots of studies talked about mathematical proficiency, so that by possessing this ability really is important for students also teachers. There are five components which mark the student's success in learning mathematics. And this five are in one thread that 'connected' with one another, such as conceptual understanding, procedural, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

*3.1 Mathematical Proficiency*

Mathematical proficiency includes five components, there are (1) conceptual understanding; (2) procedural fluency); (3) strategic competence; (4) adaptive reasoning; and (5) productive disposition. There are explanation in each component from mathematical proficiency as below. Conceptual understanding can be interpreted as students' understanding toward the mathematical concepts, operations, knowing symbols and diagrams also mathematical procedures [2]. It is the students' ability to explain the inter-linkage of learning concepts and the ability to apply these concepts flexibly, efficiently, and precisely in problem solving [7].

Regarding the achievement of conceptual understanding the concept, [8] informed the indicators to state it, such as: (1) the ability to interpret mathematical states in different ways and (2) the ability to know how different interpretations can be used for different purposes. The achievement of conceptual understanding in [9] can be seen from the students' ability in: (1) restating the learned concept; (2) classifying objects based on whether the conditions form the concept or not; (3) identifying the nature of operation or concept; (4) applying the concept logically; (5) giving some in form of both examples and non-examples; (6) presenting concepts in various forms of mathematical representation (tables, graphs, diagrams, sketches, mathematical models, etc.); (7) linking various concepts whether in mathematics or out of it and (8) developing the necessary and/or sufficient conditions of a concept.

Provides examples in understanding the concept which students have [2]. Students who understand the concept of fractions are not only able to determine the completion of $6 \div \frac{2}{3} = 9$, but they also are able to represent these operations in other forms, for examples, diagrams. Furthermore, it is explained that students who learned through understanding concepts will need faster duration to understand, because they see the general patterns used in different situations. Students have organized their knowledge into one coherent unit, which allows them to learn new ideas with what they already possessed [2].

Stated that understanding concepts is needed by students in solving mathematical problems [10]. However, the understanding concept possessed by students will be vary, due to students' errors in it. In the results from [11], it mentioned that the causes of misconceptions in general concepts came from the students, teachers, textbooks, contexts, and ways of teaching. Furthermore, it is said that the number of mistakes made by students in solving problems can be a clue to the extent of students' mastery of the material.

The next mathematical proficiency is procedural fluency. [2] stated that procedural fluency is a students' skill which includes knowledge of procedures where students are able to develop flexibility, accuracy and efficiency in solving a problem. It is also in line with what [1] wrote that procedural fluency refers to knowledge of procedures, namely when and how to use there procedures appropriately and the ability to carry out procedures flexibly, accurately and efficiently. Stated that procedural fluency consisted of three aspects [12], namely efficiency, accuracy, and flexibility. Efficiency means that students do not stop at many steps. Accuracy refers to careful workmanship, the knowledge of numbers combination also focus to the result by repeated checking. Last but not least, flexibility means that when the students try to solve a problem, it is not only focus on one method, but more other methods or strategy, which then it can adjust its use.

One of the characteristics of students who possessing procedural knowledge is that there are steps sequence to be taken in problem-solving [13]. It is mentioned that procedural knowledge was reflected through students' computational or manipulative abilities and their knowledge in identifying mathematical objects, algorithms and definitions. A procedure is a process arranged as logical and systematic steps that can be developed through problem-solving. Therefore, procedural knowledge will vary depending on the given problem. This makes students to gain the knowledge that mathematics is a structured, organized and patterned science. They could gain it by studying algorithms as a general procedure, so that if the development of procedures is carried out maximally, it will become a way to solve the problem [2]. From the description before, it acquires indicators that a student who possessed a procedural fluency is an individual who can : (1) using procedures; (2) utilizing it; (3) choosing it; (4) estimating the result of it; (5) changing the form of a procedure and (6) developing a procedure [1].

Other components from mathematical proficiency is strategic competence. [2] formulated it as a students' ability in formulating, presenting, and solving mathematical problems. This statement is similar to [14], yet an addition from them that it is also the core of other components. It is because that when a student have well-strategic competence, he or she will also have other competences such as the understanding the concept, procedural fluency, adaptive understanding, and productive disposition.

Furthermore, strategic competence is the skill to know and use the strategic to analyze and solve the problems with an aim to the learning of mathematics content [15]. Designing strategies to solve the problems mathematically has involved controls that direct students to recognize, formulate, and solve the problems effectively [16]. This term is contained in one of the objectives of learning mathematics, which is problem-solving that include the ability to understand the problems, the ability to design mathematical models, solve it and the ability to interpret the result obtained [3]. However, the result of [17] showed that the problem-solving ability is still lacking. There, the indicators used in measuring students' mathematical strategic competence based on [2], such as: (1) understand the problem, (2) select the appropriate information, (3) present the

problem in mathematical representation, (4) determining its solving strategy, (5) using and develop it, and (6) interpreting the solution.

Hereafter, there is adaptive reasoning which leads to the capacity to think logically about the linkage between concepts and situations, reflective thinking skills, the skill of explain and provide justification [1]. [2] suggested that this component includes deductive reasoning, intuition and formal proof in a deductive manner. It then can be interpreted that adaptive reasoning has a broader scope that other reasoning [18]. Adaptive reasoning does not only emphasize so students can solve the problems, but also requires students to think logically and use their reasoning correctly [19]. Furthermore, this component is important to be trained and developed, so that the students will not assume that mathematics is the only lesson which uses formula without knowing its meaning [20]. [1] mentioned that this component also has its indicator, such as (1) give reasons for the given answers; (2) determine the pattern of a mathematical phenomenon; (3) set a presumption; (4) draw a conclusion and the validity of the argument. These five indicators were chosen based on [2] as the component emphasized the ability on inductive and deductive reasoning.

Productive disposition is known as the last mathematical proficiency competence. [2] argued that this it is as a view towards mathematics as a reasonable and useful matter. It is known as an input from teacher's motivation, beliefs also attitudes towards mathematics from the subject, teaching and learning of mathematics [21]. In line with it, [1] stated that productive disposition has related to the student's tendency to have productive activities and to see that mathematics as a logical, useful and meaningful matter which possessed self-confidence in learning mathematics.

### *3.2 Results in Students' Mathematical Proficiency*

The first component, conceptual understanding, it becomes very important as it is one of the school learning goals in mathematics by [22]. It is written down that students have the ability to understand the concepts, explain the inter-linkage of concept and apply it flexibly, accurately, efficiently and appropriately in problem-solving [22]. Therefore, it needs special attention from teacher, considering that the ability as a basic for students in mathematics [23]. In fact, there still less of conceptual understanding ability possessed by students in the field. The results of a research by [24], regarding errors and causes from tenth grade of SMAN 1 Kendal, it solved the lesson problems of distance on solid figure where 66,67% of the six research subjects made mistakes in understanding the problem. In addition, another results by [25] that of 70 students, regarding the identification of their errors in solving geometry material which refers to the problem of three-dimensional. The concept errors obtained by students, including 40 students got wrong answer on the distance concept and 25 students on the concept of angles.

A research by [23] on tenth grade of SMA Harapan in Landak Regency 2016/2017 with a sample of 30 students, found that the delivery of concepts in mathematics learning was given by memorization so that students tended to expository [23]. Thus, the learning tends to be teacher-centered and emphasize procedural process, also lacks in giving opportunity to students to develop own conceptual understanding and explore the knowledge toward the concept understanding itself. Furthermore, the learning process uses *problem-solving* can improve the conceptual understanding in solid figure material.

A similar result by [26] that is the conceptual understanding skill by sixth grade students of SMAN 6 Semarang is still low. In this research, the implementation of *trajectory learning* strategy improved the conceptual understanding of sixth grade students. In line with it, [10] claimed that the thing which become as the students' error in solving the fraction operation problems is the concept understanding of the fraction operation concept itself and *scaffolding* given by teacher is very necessary [10]. A result by [27] mentioned that there is one which become the cause of student's lack in procedural fluency. It is because of the practices to train given procedural fluency during the learning are lacking. The less of this components, the more students experienced difficulties to deepen the understanding of mathematical concept or to mathematical problem-solving [2]

Concluded that students deal with the problem by reading while listening to the audio which strategy used to get information easier [28]. Thus, the students will draw a sketch based on the given information. It is showed that student directly forms a mental image from the content of a problem during reading the question. It is consistent to [2] that to present a problem correctly and appropriately, students need to understand it and form a mental image. *Open-ended* issue is one of the issues that used as a tool to improve adaptive reasoning. According to a research by [29], to develop the students' reasoning ability, the teacher should familiarize the students with problems which possessing various solutions.

Students' attitude towards mathematics is included in productive disposition, [30] believed that there is less of positive attitude by students in learning mathematics. It can be seen from the student's lack-attention towards teacher. Then became less-enthusiastic because the method used is still by lecturing. A similar matter is said that students' disposition have not been achieved overall yet, as the learning typically a teacher-centered and has not developed a mathematical thinking ability [31]. For further, this 'yet-to-be achieved' of productive disposition issue became indicated when students with non-routine problems given, they felt reluctant to work on it [23]. It indicates as 'yet-to-be realized' of students' positive attitudes towards mathematics and their self-confidence also curiosity toward the 'concepts understanding' which have been learned. So, to connect between those concepts will be difficult and it will effect to the lack of achievement of learning goals [22].

## 4. Conclusion and Suggestion

There are five components of mathematical proficiency which indicated the students' success in learning mathematics. These components are one strand which connected to one another, such as conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. From some research reviews, there is lack of students' mathematical proficiency in Indonesia. It means that there is effort needed to improve it. Indeed, these matters involve all related components such as a competent mathematics teacher, the mathematical curriculum which ensure the students' opportunity to learn the mathematics meaningful concepts and procedures, text books that supported the development of mathematics proficiency, also learning strategy used by teachers to improve this skill. Thus, it is proven that mathematical proficiency is not something which apart, which means that it cannot be accomplished with merely focusing on one component itself [2]. There, mathematical proficiency is not a separated domain, those five are interacted to reinforce one's knowledge, skills, abilities and beliefs [4]. The education in mathematics should prepare students to deal with the changing circumstances and mindsets in life and also preparing them to use mathematical mindsets in everyday life [5]. Therefore, it is important to direct the mathematical learning so that the thinking skill can be trained mathematically. One way that can be done is through the development of the five components mentioned before.

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# The Use of Social Media in On-line Video Learning System on Algebraic

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**Abstract**. The development of information technology and industry revolution 4.0 produce increasingly effective learning processes. Digitalization and delivery of messages through social media is becoming a trend nowadays for young people, as well as information technology for students whose daily activities are related to digital and internet. It is important to make students whose major is informatics engineering interesting to learn theory algebra. They more interest in computer related things (hardware) or its application (software) than the basic theory of computer like algebra. Algebra material has its own challenges in informatics engineering students. Active learning is highly recommended in this learning and using social media is the way to learn algebra. The research method used a case study. The purpose of the case study is to identify the use of social media, especially online video such as YouTube in the learning process of Algebra and find out the students' responses to the use of the internet in the Algebra learning process. In this case is making students open the mind for study algebra. Video creations from students can be seen on social media so that other students can learn. From making videos, students learn not only interesting video making techniques but also algebra material. They also learn the use of programs that support for making and editing video. This research discuss about how effective the use of social media in learning on-line video systems on algebra material.

## 1. Introduction

The globalization has entered Indonesia, it accompanied by increasingly sophisticated technological developments. The world is now entering the era of the industrial revolution 4.0, which emphasizes the patterns of digital economy, artificial intelligence, big data, robotic, etc. or known as the phenomenon of disruptive innovation as well as at Indonesian country. [1] The computer and electronic network are likely to have significant effects on education, and it is important to consider that impact. The new technology is better than presentation through textbooks. Furthermore, the new technology was more effective than presentation through lectures. The role of the teacher for conducting learning is still needed. This is called humane process, and it is not quite right that technology always gives birth to a process of dehumanization. Technology support practitioners classroom teachers who need to be trained in developing constructivist learning environments. Building bridges between research on learning and teaching and classroom teachers can provide the practitioner community and students with the benefits of the research efforts [2]. Learning with technology allows teachers to interact together with students in where ever they are. Facing these challenges, teaching in higher education is also demanded to change, including in producing quality lecturers for future generations. The higher education policy must also be adjusted to the conditions of the 4.0 revolution. There are changes in policies and programs related to the science and technology resources of the Higher Education, institutions, learning and student affairs, as well as research and development as well as innovation. Changes in the field of resources are very important, including developing the capacity of lecturers and tutors in online learning. So this lecturer also acts as a tutor. Then the development of MOOC (Massive Open Online Course) infrastructure, teaching industry, and e-library is actually already running.

Active learning involves providing opportunities for students to meaningfully talk and listen, write, read, and reflect on the content, ideas, issues, and concerns of an academic subject [8]. Active learning is generally defined as any instructional method that engages students in the learning process. In short,

active learning ordered students to do meaningful learning activities and think about what they are doing. While this definition could include traditional activities such as homework. Active learning is often contrasted to the traditional lecture where students passively receive information from the teacher. In traditional lecture, students just sit and listen the teacher or just drill the problem solving by themselves. But active learning, the activities are discuss range from listening practices, require students to absorb what they hear from dicussing, to short writing exercises in which students react to lecture material, to complex group exercises. Through active learning and technologyenabled flipped classroom strategies, students may develop higher order thinking skills and creativity

Messaging through social media is becoming a trend nowadays for young people, as well as informatics engineering students who are daily related to the internet. Social media provides the opportunity to interact more closely with friends or relations, it can be a medium for forming online communities. Social networking provide various benefits to the students and teachers. It is very easy to educate from others who are experts and professionals from the social media. One can follow anyone to learn from him/her and enhance his knowledge about any field. Regardless of our location and education background we can educate ourself, without paying for it [3]. Social media provides opportunities to enter pre-existing communities and provides opportunities to get direct feedback. Various practices can be done by every student, for example using YouTube media in learning [4]. It is evident that YouTube videos brought about positive effects on teaching and learning in various disciplines. Morison, Ross, & Kemp state that learning can improve when students are actively involved in the learning process [5]. Students said actively involved in learning when students can access and manage their own presentation material. They will be more interested in what is learned. They can understand the material by themselves, although it need discuss between groups or with lecture. Thus, it is important to develop a lesson plan that involves students actively in the learning process. For addition, the learning process must be organized clearly and systematically. So, this paper is discuss about learning within social media such as making Youtube video. It is new idea for informatics engineering student of Muammadiyah Sorong University in Sorong Papua for learning algebra especially dicrete mathematics by making video on youtube. They usually learn algebra with drilling method and listen to the lecture. So it was interested to be discussed and given an idea to lecture for teaching exact material like mathematics in engineering student especially informatics engineering. Furthermore, informatics engineering students need active learning using their computer for learn Algebra. This paper give an idea for learning algebra in discrete mathematics using social media by making video online on youtube.

## 2. Theoretical background

*2.2 Active Learning.*

Active and cooperative learning methods recognize that the passive model of the typical college lecture does not work for many students. The active and cooperative learning focuses that students can learn best by doing and working with each other [7]. In traditional learning of class periods, students listen to lecture for about an hour. Cooperative learning can replace some of that lecture time with methods designed to get students actively involved during the class period. This paper presents the use of active and cooperative learning techniques applied on Algebra in Informatics Engineering at Muhammadiyah Sorong University.

In the middle of Mathematics Diskret schedule, student of informatics engineering without their computer have to listen theory of Algebra. At least a third of the students are texting or sleeping or chatting with other. Many of them clearly don't understand much of what lecture saying and the semester exam score prove it, but they never ask questions about the difficulties. It's been like this since the beginning of the semester and the lecture getting desperate. its brings up idea to try something different. The lecture make students get into groups some waking their neighbors in the process and go to work make a script for their assessment. This ‘active learning’ to describe a classroom approach which acknowledges that students are active in the learning process by building knowledge and understanding in response to learning opportunities provided by their lecture. For this, active learning means that students take responsibility for their learning, and lecture are the fasilitator and observator of learning,

rather than lecturers or deliverers of ideas. Its contrasts with a model of instruction which knowledge is imparted or transmitted from the lecture to students.
. In practice, active learning refers to activities that students and lecture have to collaborate in learning, such as the students manage the material and lecture lead the discuss. The core elements of active learning are student activity and engagement in the learning process.. The effective application of vital competencies are critical thinking, creativity, communication, and collaboration. . In addition, it is crucial for graduating students for succeed in the workplace. So that it using active learning to making script for Youtube video related to the material of discrete mathematics

*2.3 Online learning: More effective and challenge.*

Terms commonly used for online learning include e-learning, internet learning, distributed learning, networked learning, tele-learning, virtual learning, computer-assisted learning, web-based learning, and distance learning. All of these terms used for the learner because they have a distance from the tutor or lecture, that the learner uses some form of technology such as a computer to access the learning materials. So that the learner uses that technology to interact with the tutor or lecture and with other students. It is form of support provided to students [9].

For students, online learning knows no time zones, and location and distance are not in problem. In online learning, students can access the online materials anytime, while synchronous online learning allows for real-time interaction between students and lectures. Students can use the Internet to access up to date and relevant learning materials, and can communicate with experts in the field which they are studying. The goal of any instructional system is to promote learning. Therefore, before any learning materials are developed, educators must tacitly or explicitly know the principles of learning and how students learn. This is especially true for online learning, where lectures and students are separated. The development of effective online learning materials should be based on proven and sound learning theories [10]

- Students should get the explicit outcomes of the learning so they can set expectations and judge for themselves so they can rate what they have achieved the outcome in the online lesson.
- Students must be tested or get examination to determine what they have achieved in the learning outcome. Online testing or some exams and assessment should be integrated into the learning sequence to check individual student's achievement level and provide appropriate feedback.
- The learning materials must be sequenced appropriately to promote learning. The sequencing could take the form of simple to complex, known to unknown, and knowledge to application.
- Students must be provided with feedback so that they can monitor and rate what they are done and take corrective action if required.

For this paper, online learning is a tool for collect the material of discret mathematics when the students making script before making the videos. The student should worked with computer to learn in e-learning or internet learning, network learning etc. In online learning environment, a social community of students who share knowledge, values, and goals. A sense of community in online learning is comprised of two components

- Connectedness, which refers to student's feelings of cohesion, spirit, trust and interdependence, and
- Learning, which refers to the students' feelings of the extent to which their learning goals and expectations are satisfied.

In case, students will upload their video on Youtube. It can be said that the online videos are online learning too.

However, extrinsic motivation should also be used since some students are motivated by externally driven methods. Keller proposes the ARCS model (Attention, Relevance, Confidence, Satisfaction) for motivating students:

- Attention: Capture the students' attention at the start of the lesson and maintain it throughout the lesson. The online learning materials must include an activity at the start of the learning session to connect with the students.

- Relevance: Inform students of the importance of the lesson and how taking the lesson could benefit them. Strategies could include describing how students will benefit from taking the lesson, and how they can use what they learn in real-life situations. This strategy helps to contextualize the learning and make it more meaningful, thereby maintaining students' interest throughout the learning session.
- Confidence: Use strategies such as designing for success and informing students of the lesson expectations. Design for success Foundations of Educational Theory for Online Learning 29 by sequencing from simple to complex, or from known to unknown, and use a competency-based approach where students are given the opportunity to use different strategies to complete the lesson. Inform students of the lesson outcome and provide ongoing encouragement to complete the lesson.
- Satisfaction: Provide feedback on students' performance and allow them to apply what they learn in real-life situations. Students like to know how they are doing, and they like to contextualize what they are learning by applying the information in real life

It is availability of the internet so that teachers are having greater opportunity to access into various educational tools which can be used to enhance the practice of student-centered learning in the classroom and to engage in a lot of interactions with students. It is beneficial for student too so that student can learn online material from videos, slides, games, interactive software. Its found to assist teachers in carrying out their teaching and learning. Teachers would have to accept that with the development of social media and educational technologies, content knowledge can be generated and disseminated more quickly and widely than before.

*2.4 Social Media.*

Social media enable students to easily contact with each other with regard to their projects and assignments. Students also can work on group assignments from their home. It is used by student which is college in informatics engineering of Muhammadiyah Sorong University. Almost of them open and use social media everyday. Somehow social media is used in pedagogy students who have difficulty in expressing their thoughts in the classroom. This social media can get involved in the learning process, it helps to build their confidence level as well. Any doubts can be clarified by posting a message through the social media. A site like Instagram, Facebook, Youtube help teachers to stay in touch with their students or to know the activity of their student. Students are learning the skill sets required for successful social networking [11]. Social media also brings with the freedom for students to connect and collaborate outside of institutional boundaries as well as to gain practical experience for the workforce . Students are also being taught new concepts like online privacy. Video can be a powerful educational and motivational tool. Video is a means toward achieving learning goals and objectives. Effective instructional video is not television to student instruction but rather teacher-tostudent instruction, with video as a vehicle for discovery. Other researchers have found that YouTube is effective for increasing skills both in a lab setting and in the general public as well as long-term retention of material. Thus, YouTube is being continually validated as an effective tool for teaching in a formal setting or in the home for common skills and tasks.

The role of the social media for learner is to allow the group to be emergent in their learning. To allow the participants to seek their own rhythms and ways of working together. To keep a close watch on the group without interfering but being ready to assist. To use advanced organisers to build a pedagogical framework for participants to use when they are ready. To create specific scaffolding contexts SNSs can become an incredible tool in collaborative work; the didactic possibilities afforded by these tools are almost endless when they are intended to promote interaction between the group, between the group and the teacher, and among teachers, all of which takes place outside the time and spatial constraints of a school environment.

Social networks are applications that support enthusiasm in a common space around sharing interests, collaborations, resource sharing, communications and interactions. The teachers can communicate instantly and directly with the students and compare notes on education techniques, curriculum and teaching methodology and so on. Teachers, professors and academics routinely used blogs to write about

the world of education and invite comments from all over the world. The impact of social media is radically changing the way education has been traditionally delivered. Students should develop the cognitive and intuitive ability to analyse how much time they spent with social media. It is up to the students to decide what really matters in their life and how much of this virtual life translates to real life. In spite of those concerns, however, the faculty believes a social media sites offer value in teaching. An overwhelming majority report that they believe that video, podcast, and wikis re valuable tools for teaching, and a majority report that social media sites can be valuable tools for collaborative learning.

*2.5Youtube*

YouTube is the biggest and most well known video-based online networking site. It was established on February 14, 2005 by three previous PayPal workers. It was later purchased by Google in November 2006 for $1.65 billion. YouTube has more than 1 billion site guests for every month and is the second most well known internet searcher behind Google. YouTube is an excellent option of flipping classroom so that students can watch lectures and resources before entering the classroom [12]. It is like blogging, since the material will be seen by a wider audience, students will be more to do their very best in creating a video, and they will enjoy being able to express their creativity as they connect more deeply with the course material. Some results showed that the You Tube tutorial methodology had a significant positive effect on perceived student learning. YouTube videos create a novel way of conveying educational content through real-life situations and observations, as well as connecting students with external experts. Using social media platforms associated with popular culture can also become a tool in which students can actively pursue learning on their own accord.

Media content is now accessed via the Internet and through 4.0 technologies where users interact and collaborate to create content . Such social media sites allow people to share and generate information with the rest of the world. The website "YouTube" is one source of social media that has grown in popularity over the past five years, including its use in the classroom as an educational tool. YouTube was launched in 2005 as a place where individuals could record and share their own videos without cost. The website is now owned by Google and is viewed daily by millions of individuals across the world. Although much of the content on YouTube is for entertainment purposes, there exists an enormity of educational content. For example, YouTube EDU was created in 2009 as an educational hub for lectures, courses, and examples and is used by professionals and nonprofessionals in a variety of fields. While the use of YouTube in higher education is not new, its prevalence as an educational tool in regards to best practices and student outcomes. The current study provides a literature review that focuses on the usefulness of YouTube media as a form of lecture support and conversation starter in the classroom. In this paper, student use YouTube as media which means place of online learning so that students can learn and discuss about discrete mathematics. The student of informatics engineering share video about the topic of discrete mathematics on YouTube then they can freely discuss it on comment or in class.

## 3. Method

The research method used a case study. The purpose of the case study is to identify the use of social media, especially online video such as YouTube in the learning process of Algebra and find out the students' responses to the use of the internet in the Algebra learning process. The goal is to understand the activities of lecturers and students in the Algebra learning process. Therefore, the case study approach is a qualitative approach. Through a qualitative approach it is expected to gain a deep understanding and interpretation of the meaning of relevant facts [6]. The research subjects were informatics engineering students in the learning process of Algebra. This study involves some very detailed, in-depth, and detailed examination of the case. It needs to understand the responses and behaviors associated with the process of learning mathematics that are the focus of research. The involvement of researchers in the learning process is a demand in order to understand the facts of occur.

The research was conducted in the Department of Informatics, University of Muhammadiyah Sorong, West Papua. While the research was conducted from March until June 2020. To get an in-depth overview of the use of social media in the Algebra learning process which is the use of Youtube, students

had been introduced online video. Online video provided through YouTube social media about Algebra material, then lecture gave assessment for informatics engineering students to the opportunity of creating online videos. Student were formed into groups. For each group had make video according to the material provided. Each group consists of 2 students. Data collection through several stages as follows observation as a data collection technique relying on the senses of the eyes and ears carried out with the involvement of researchers in research settings. Complete participatory observation aims to determine the process of utilizing social media in a comprehensive manner. Observations were made covering all activities of lecturer and students in algebra learning. Data reduction is used to summarize, focus on important things, and delete data that are not patterned from the results of observations and interviews and data from the study documents. Triangulation is used to check the accuracy of data obtained by comparing data from observations, interviews and document studies.

## 4. Result

In this research using a descriptive approach, the lecture as writer must describe, explain and illustrate the data obtained through observations on learning, videos and interviews conducted with students. The results of this study can be translated into three parts. The part is the Online-learning process, the process of making videos for students of informatics engineering, and students' responses to learning.

### *5.2 Online-Learning Process*

In this study, the lecturer conveys an Online-learning strategy at the beginning of the lecture. By discussing the basic of theory, students are then assigned to access Algebra material with the theme of Discrete Mathematics, each group of students has an assignment according to the title given. These titles are integers, mathematical logic, and functions. The material can be accessed via google, then students can study it before submitting according to their understanding. After that, students make videos in groups according to the material assigned. Videos can be interactive learning videos (digital video or analog video), gaming videos, or presentations. Making a video can use several programs such as video maker, film maker, powerpoint, camtasia, or others. Need 1 month to work on that video. Furthermore, the results of the video uploaded to social media, YouTube. From YouTube students can see each other's video results with different material. Students can also exchange comments and discuss on YouTube. Not only informatics engineering students at the University of Muhammadiyah Sorong can see it but also other social media users. On the Online-learning strategy [13]give in this paper can be described as follows:

- Attention: doing interesting learning, in fact Algebra lessons are less attractive to Informatics Engineering students. In this learning, students being aware. Student learn Algebra by using their abilities according to their majors or hobbies, namely making videos
- Relevance: Provides an understanding of Algebra in particular Discrete Mathematics and solving algebra problems through interesting methods.
- Confidence: forming the confidence of informatics engineering students in understanding Algebra material by making the presentation of Algebra material on Youtube.
- Satisfaction: a matter of pride when making videos and showing them on social media, YouTube.

### *5.3 Making Video-Process*

Making the YouTube video was a straight forward process - develop an idea into an organized script, and then shoot the clip. Three different video designs are tested. Design 1 differs significantly from designs 2 and 3. Design 1 was developed and tested first. Following analysis of its survey results and consideration of anecdotal comments from students for design improvement, design 2 was developed. Design 2 was tested in a following course-term. Then, following analysis of the design 2 survey results, design 3 was developed and tested [14]. In making YouTube videos and uploads, there are a number of things that need attention for lecture as follows:

*5.3.1 Planning*

The participants become more engaged in their learning and develop critical thinking. This can be seen from the discussion in lectures and the YouTube link comments after seeing the YouTube video. In the first round of the research, lecture deliver plan to use making video and share via YouTube so videos relevant to the topic of discussion and make an activity such as see video others and comment or discuss the material. The lecture give an example of video on Youtube such as a presentation, game, learning video,etc.

*5.3.2 Acting*

Student should carry out the activity in making video such as make script, learn the theory. First, students were briefed about the activities and the plan of assesment.

*6.2.3 Observing*

The lecture watch the video on YouTube and assess things conveyed through video in accordance with the theory. Is the video interesting, easy to understanding or whether the video in accordance with the reference material. Is the video interesting to watch and is the video have comment related to the discrete mathematics or something else.

*6.2.4 Reflecting*

Have lecture overlooked the needs of the participants to ask question on YouTube and share experiences for making video on YouTube. The lecture should discuss the video in class.

The intention of the study are about ability to make video and accordance with the theory. In the making process, the video that will be displayed on YouTube has the following characters:

- Displays images with motion, as well as sound simultaneously.
- Able to explain Discrete Mathematical material (logic, integers, functions) along with examples and problem solving
- Using engineering (animation).
- Does not require special expertise in making and editing video
- The idea of making comes from books and the internet

From making videos, students learn to cooperate with each other in the making. This shows that active learning is going well. Students form a group with 4 members, then discuss with each other. Each member has their own duties, divided into draftsman, player, picture taker, editor. However, here students can also work in 2 tasks such as drafting scripts as well as players. Students here are required to complete the project according to group decisions and set the time for making videos. Figure 1 is one example of making video from a group student.


**Figure 1**. YouTube Video with Function Theory

### *5.4 Student Responses*

The main objectives of this study was to examine the extent in which The Use of Social Media in On-line Video Learning System on Algebraic. Our findings indicated that generally the students had a positive view of The Use of Social Media in On-line Video Learning System on Algebraic by making video for YouTube. They mentioned that making YouTube videos made the lesson fun and interesting, were relevant and managed to attract their attention. Making YouTube video makes the lesson fun and interesting, beneficial–active learning-concept understanding-Remember Better-Effective

Students A and B mentioned that making YouTube videos were interesting not like the traditional lecture using textbook or just listen the theory and it was more memorable and they learned better.

"…I felt that it is a good way learn Algebra more interesting. Instead of conducting a lecture by using a textbook,or just listen teacher said. This way by making video, I can manage what I learn about dicrete mathematics and look for the theory bymyself then we share on video. As a student, I honestly think that this way of learning is more beneficial since I can remember what I learn better than listening to the lecturer talk all the time…"

(Reflection Student A)

Student C liked the idea of upload videos on YouTube, interesting and "new".

"…In my opinion, I feel proud to be YouTuber and share knowledge about Graf Theory as discret mathematics. it is new for me for making video on YouTube"

(Reflection Student C)

Similarly, Student D explained that he learned better because he could understand the concept of Function by arrange the video, not only answer the question or problem solving. He discuss Function for preproduction on making video with his group. On this part the active learning did well.

"…I am in the opinion that video as a means of delivering lecture is very effective because I am such a person who learns quickly through what I do. It also makes me understand the concept of Function by arrange the video, discuss about my friend when determined the script of video not only answer the question or problem solving"

(Reflection Student D)

Student E explained that not only videos attracted their attention, but they were found to be beneficial to their learning as they learned with a purpose to focus on specific information. Eventually, they learned leave notes or comment while viewing the other videos on YouTube. And also subscribe the YouTube channel.

"I can use some application for editing video, it make us learn about editing video. Showing video can attract the other students' attention and if our video seen many student and subcribed, its so excited that means our video have been watched. Its happier when somebody leave the notes or comment in our link YouTube. it make us challenged"

(Reflection Student E and F)

## 6. **Conclusion**

Making a video through the stages is quite long. The stages must be done sequentially, they cannot jump from stage one directly to stage three. The stages are preproduction, production and post-production. The truth in carrying out each stage guarantees the truth at the next stage. The making of this video is teamwork. The cohesiveness of the elements involved at each stage will determine the quality of the product produced. The preproduction stage involves the lecturer, namely the determination of the material to be presented in the video, while the script writer, and the media expert (image maker and editor) involve the students themselves. Making videos uploaded on YouTube at this writing to face the education era 4.0 which refers to cyber physical systems using 3D printing. Furthermore, learning is carried out using active learning that is competent in critical thinking, creativity, communication, and collaboration in video making. In making videos, students of informatics engineering are also honed in

their ability to make videos as interesting as possible by using several animations, video making programs, or editing processes.

This makes students feel challenged by using ideas, hobbies, and abilities in accordance with the vocational field of informatics engineering in studying Algebra especially discrete mathematics. This form the character of persistence and leadership in group discussions. Its need somethings to consider when using social media for education, in this case is making YouTube video. The first is sharing knowledge, it provides an easy and an effective way for students so they can share knowledge. Students can simply access the information, study, transform and share. Second, learning from various sources so the students can search the material from many sources. The long range interpersonal communication advances are worked in such a way, to the point that understudies will have the capacity to pick the gathering and movement The ways of learning is plenty. Third, being prepared is to prepare material for conveyed via YouTube, in this case is discrete mathematics. The social networking technologies are all about showcasing the theory. Students should setup a plan of what might be expected out of them by observed, shared, discussed or spoken. The last is for sharing what they feel or think. Through social media they are given an option to sound their thoughts. So in Youtube as informatics engineering student, they can enjoy making video but learn algebra too. On YouTube they can sharing about discrete mathematics in comment column. They can ask freely about the topics because each group make different video. If students were permitted to share what they think and feel, it becomes simple for them to decide what they understand.

From this study, we found that social media in on-line video learning system on algebraic which is in case You Tube project design and development process experience connected with increased student perceptions of learning. The shared comments of participants produced an increased awareness of how students described their relationship with the project, how they gained learning strategies, and how they perceived derived benefits of tutorial learning through both the MovieMaker and You Tube processes. Specifically, they learn Algebra by presented on YouTube and they were able to see more potential benefits of incorporating YouTube into their experiences. It would better if there is test of result the effectiveness by some discrete mathematics test, it can be planed on next research. It is important to make students whose major is informatics engineering interesting to learn theory algebra. They more interest in computer related things (hardware) or its application (software) than the basic theory of computer like algebra. In this case is make students open the mind for study algebra. For conceptual understanding when they learn math discrete or algebra through video, has not been studied further.

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# Transposition from Knowledge to be Taught to Knowledge Actually Taught and Its Impact to Students' Concept Image on Set Concept

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**Abstract**. This study aimed to analysis of transposition process from knowledge to be taught to knowledge actually taught, concerning the concept of set, and its impact to students' concept image. We analysed set concepts presented by school mathematics textbook and presented by teacher in teaching and learning process, and the impact of this didactic transposition on students' concept image. This study was a qualitative study with interpretive phenomenology analysis approach. We found that in knowledge to be taught and knowledge actually taught, a set is defined as well-defined collection of objects. However, there is difference in the meaning of the term "well-defined" in both. This difference in meaning showed the inaccuracy of the presentation of knowledge actually taught. This transposition of knowledge caused zone of concept image differences between students' concept images and formal concept definitions in scholarly knowledge.

## 1. Introduction

Teachers faces two main problems in teaching practice, namely curriculum management and classroom management [1]. The curriculum management concerns the construction of academic knowledge which later becomes the object of teaching. Class management concerns didactic situations that are presented to help students construct their knowledge. The construction of academic knowledge into the object of teaching through a series of transposition processes, starting from scholarly knowledge to knowledge learned by students. This process is known as didactic transposition [2,3].

The process of transforming scholarly knowledge into objects of teaching is called external didactic transposition. In this process, scholarly knowledge was re-contextualized according to the context of learning, so that scholarly knowledge becomes knowledge to be taught. Furthermore, scholarly knowledge that had become the object of teaching was transformed back into an object of knowledge that is actually taught by the teacher in the classroom. This transformation process is called an internal didactic transposition [1].

In the didactic transposition process, the important thing that must be considered by the teacher is not only didactic action but also anticipating the interactive and symbolic activities that occur in the

classroom. Thus, even though teachers have a curriculum as a guide in teaching, often the knowledge actually taught in the classroom is different from the knowledge to be taught. It was due to every teacher having different interpretation of a concept and experiences related to their professional experiences.

Meanwhile, the implementation of knowledge actually taught had an effect on the knowledge that will be learned by students. Concept images are used to describe the total cognitive structure associated with the concept, characteristics and the process of mental pictures in a person's mind can explain the construction of knowledge that students learn [4,5]. Therefore, in the process of transposition from knowledge to be taught to knowledge actually taught, the teacher must pay attention to the accuracy of the presentation of concepts and didactic situations.

The transposition of knowledge in this study refers to the transposition of the concept of set. The concept of a set is one of fundamental object in mathematics [6]. The concept of set has undergone a process of transposition to become an object of teaching and it is included in the school mathematics curriculum for 7$^{th}$ grade. In this study, we analysed the transposition process from knowledge to be taught to knowledge actually taught, concerning the concept of set and the impact of this transposition to students' concept image.

## 2. Methods

This study is a qualitative with interpretive phenomenology analysis (IPA) approach, which aimed to interpret a phenomenon based on human experiences [7]. Human experience which is a phenomenon observed in this study is how the process carried out by the teacher in transmitting knowledge from knowledge to be taught to knowledge actually taught, concerning concept of set (Fig. 1). This study focuses on the analysis of the concept of set as knowledge to be taught, the analysis of the didactic transposition from knowledge to be taught to knowledge actually taught, and the analysis of the concept image of students formed from the learning process received.

A teacher and 28 students of 7$^{th}$ grade became participants in this study. Data for our analysis was taken from literature review on school mathematics textbook, video of observation of teaching and learning process, diagnostic test, and interview with 5 students. All data were processed and analyzed using procedures in qualitative research which includes three stages, namely managing data, inductive analysis, and interpretation [8,9].

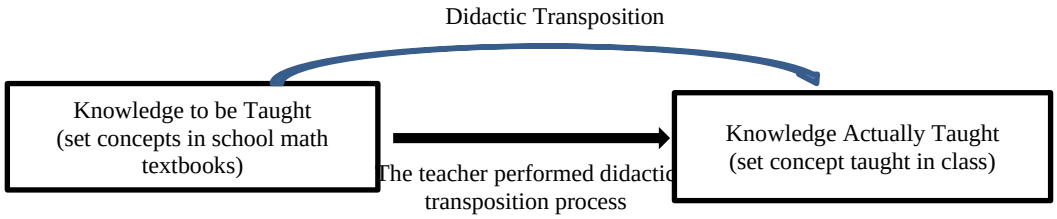


**Figure 1.** Didactic Transposition Analysis

## 3. Result and discussion

### *3.1. Result*

The results will be presented in three parts. First, analysis of the concept of set as knowledge to be taught presented by the school mathematics textbook. Second, analysis of the didactic transposition from knowledge to be taught to knowledge actually taught on the concept of set. Third, analysis of the impact of the didactic transposition on the students' concept image.

#### *3.1.1. The concept of set as a knowledge to be taught.*

The representation of the concept of set as knowledge to be taught can be seen from the presentation of the concept in school mathematics textbooks. In school mathematics textbooks, the set is defined as

a well-defined collection of objects. A collection of objects is called well defined if the object is defined according to properties that have clear measure and do not generate multiple interpretations (Fig. 2). Besides that, presentation of set concepts in school mathematics textbooks had undergone a re-contextualization process from scholarly mathematics, in which the concept of a set is brought from the context of scholarly mathematics to school mathematics with regard to conditions of the student's learning environment and students' cognitive development. This concept presentation is arranged sequentially from a concrete learning context to a more abstract learning context.

A group of students whose height is above 155 cm is an example of set because there is a clear measure between students who have a height above 155 cm and students whose height is less than 155 cm.
Students who height is a non-example of set because the word "height" does not imply a measure clear, how many cm in height, and its generate different interpretations, for example: there are people who said that height 160 is high, but there are people who said that it's not.

**Figure 2.** Examples and Non-Examples of Set [9]

Furthermore, the concept of this set is presented in a didactic situation that establish the students learning trajectory in the process of constructing the concept of the set. The description of this didactic situation is obtained from the flow of material presentation contained in student books and teacher books. The didactic situation is presented in the school mathematics textbook also contains steps for the concept construction process that begins with the presentation of contextual problems. Then from this problem, students are required to construct the concept of a set through a series of learning activities, including observing, asking, reasoning, and sharing. (Fig. 3).

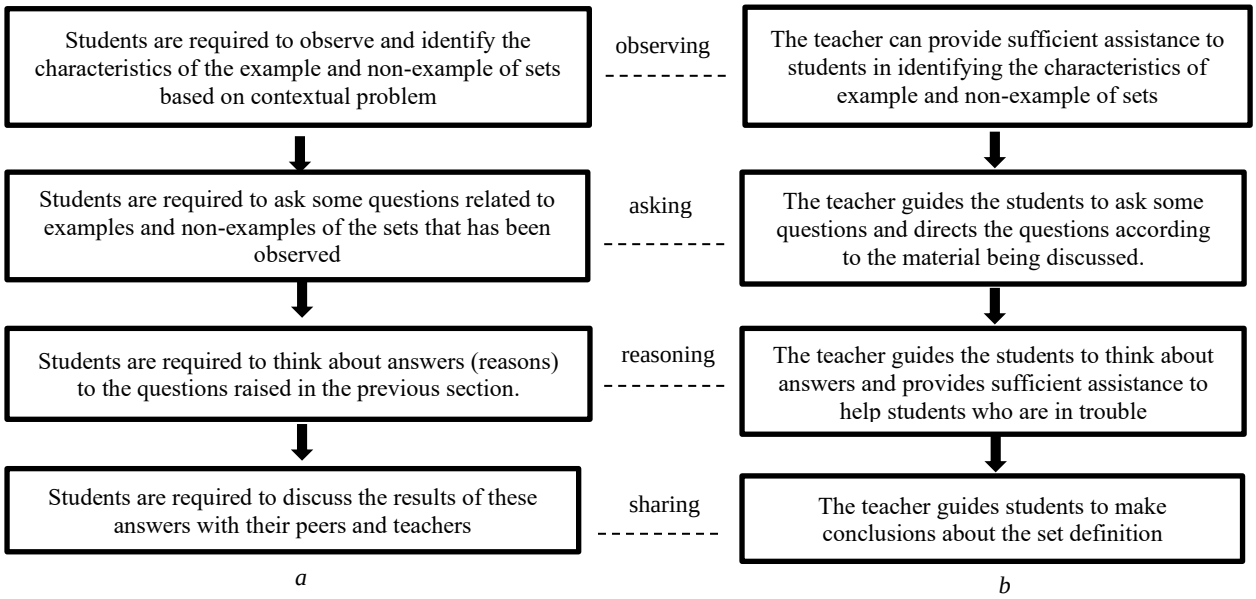


**Figure 3.** Didactic Situation in Student Book (*a*) and Teacher's Book (*b*) [10,11]

A series of didactic situations are presented to help students more easily understand the concept of sets and the end, the students can be able to construct concept of set more abstractly.

*3.1.2. Transposition of the set concept from knowledge to be taught to knowledge actually taught*

The results of observation of teaching and learning process on the set concept provide data about how the teacher presents the concept of a set as knowledge actually taught. Before discussing about how the form of a set concept presentation is as knowledge actually taught, it will first explain about how the didactic situation presented by the teacher in class to help students construct the concept of the set. This didactic situation also describes the student learning trajectory.

The didactic situation was presented by the teacher during the teaching and learning process was different from the didactic situation was presented by the school mathematics textbook. In this teaching and learning process, the didactic situation presented establish a different student learning trajectory. The teacher starts learning process with reasoning activities, which the teacher offered several problems in the form of questions as follows:

Problem 1.

T: For example, there is a statement "Group of 7th graders in ‘X” junior high school. How many students are there?

S: 30

T: Who is included in the group?

S: *(Students mention the names of student in 7$^{th}$ grade)*

T: Are the 7th grade teachers included in that group?

S: No.

T: it means the 7th grade teachers is not a member of group of 7th graders in junior high school “X".

Problem 2.

T: Okay next, "a group of 7th grade male students who have long hair". Anyone?

S: (*Students name several students*)

T: is there a clearly stated meaning of having long hair?

S: No.

Problem 3

T: Another example, "How many 7$^{th}$ grade student wear glasses?”

S: a student.

T: is it clear who the members are?

S: Yes, it is.

Problem 4

T: a group of beautiful students in 7$^{th}$ grade. Is there or not?

S: Yes. There is.

Problems 1-4 aimed to show an example of objects collection which is a set and an example of objects collection of objects which is not a set. The teacher intended to show these differences based on the clarity of the nature of the members of the group. Unfortunately, the teacher's question is referred to determining existence or did not existence of member of group had being discussed, so that a collection of objects can be said to be a set if this collection had members.

In problem 4, the teacher wants to reaffirm that the statement “the beautiful students in 7$^{th}$ grade” was not well defined.

T: in your opinion, who is a beautiful student?

S: *(The student mentions the name of the student who is considered beautiful).*

T: So, how can you define beauty?

S: the beautiful is white.

T: there are those who judge that beauty with white skin, there are those who judge that beauty with a sharp nose or with large eyes. It means that each person had different perception. So, is this statement clear?

S: No.

T: Yes, you are right. This statement is not clear.

But unfortunately, after this question, the teacher did not provide an explanation of the conclusions of the problems given. Furthermore, the teacher required the students to identify which of the four

problems, which are examples of sets and non-examples of sets. Of course, the students were confused to determine the answer of teachers' question.

T: can you determine which are example of set and non-example of set?

S: (*Students were silent)*

In this conversation, the students are still confused to determine which are examples of sets and non-examples of sets. Students' confusion was predicted because students did not know the characteristics of a group can be called a set. The problems and questions were given by the teacher also have not been able to help the process of students' thinking to understand the characteristics of a collection of objects that can be called as a set.

Seeing that there is a didactic contract that occurs in students, then the teacher explained the concept of the set.

T: set is a group of objects that can be grouped according to certain properties or the set is a group of objects that are well defined according to their properties or characters.

T: so, do you know which are examples of set and non-examples of set?

S: yes, we know (*the students answered simultaneously*).

In this section, the teacher did not explain clearly the meaning of a group of objects that are 'well defined' according to their properties. In particular, the teacher did not explain what well defined means and when an object was called 'well defined'. The teacher also did not reaffirm which collection of objects representing examples of sets and non-examples of sets, so there was no validation process to ensure students' understanding of this concept.

Based on the results of observations on this teaching and learning process, it was found that; (1) the teacher understood the set as a well-defined collection of objects. The meaning of well-defined is to have clear measurement and not cause multiple interpretations. However, in the presentation of the material, the concept of set as a knowledge actually taught was not presented completely and it was defined unclearly; (2) the didactic situation presented showed that there is a jump in the process of students' thinking. This can be seen when the teacher formed process of student thinking to determine examples and not examples of sets of several objects collection, while the process of students' thinking has not yet reached the meaning of what a set is and how the characteristics of a set.

The transposition of the set concept from knowledge to be taught to knowledge actually taught shows that there is a concept gap between the concepts presented as knowledge actually taught with the concept of a set presented as knowledge to be taught. This condition is predicted to cause learning obstacle to students, especially didactic obstacle. The existence of this didactic obstacle causes students to be constrained from constructing their knowledge of the set concept as a whole and accurately.

### *3.1.3. The impact of the transposition on students' concept image*

In an effort to check students' understanding on the concept of set and the concepts of examples and non-examples of set, a diagnostic test was carried out on 28 students in 7$^{th}$ grade. (Fig. 4).

Define examples and non-example sets of the following statements!

a. A collection of high students in 7$^{th}$ grade.
b. A collection of 7$^{th}$ grader who weigh more than 50 kg.
c. A collection of stationery

**Figure 4.** Diagnostic Test

Problem number (a) showed non-example of set and problem number (b) and (c) shows example of set. Based on the test results, it was found that 79% of students answered that question number (a) was an example of a set, 57% of students answered that question number (b) was a non-set example, and all students answered question number (c) was an example of a set. These results indicated that most

of students had not been able to determine examples and non-examples of set correctly, especially in questions (a) and (b).

The ability of students in determining examples and non-examples of set was certainly influenced by students' conception to the concept of the set itself. The mistake of most students in determining examples and non-examples of sets was an indication that there was an incomplete understanding of set concept. To obtain more detailed information about students' conception of set concept, 5 students were chosen to be interviewed with the aim of exploring students' conception through student concept image analysis.

Based on the results of the interview, it was found that S1, S4, and S5 had a concept image which showed that a group of objects is called a set if it had members.

R: Number (a), your answer showed that "a collection of high students in 7$^{th}$ grade" is an example of a set. Why?
S1: because there are high students.
S4: because there are high students in 7$^{th}$ grade.
S5: because there is high student
R: Number (b), there is a statement "a collection of 7$^{th}$ grader who weigh more than 50 kg". is it example of set or non-example of set? And why?
S4: it is a set. Because there are students who weigh more than 50 kg.
S5: it is a set. Because there are students who weigh more than 50 kg.

Meanwhile, S2 and S3 had a concept image which showed that a collection of objects can be called a set if it had many members.

R: Number (a), is it an example of set or non-example of set?
S2: No, it is not. Because not all students in 7$^{th}$ grade are high.
S3: No. because in that class there are no many of high students.

The results of these tests and interviews provided an overview of the student's concept image which showed that a collection of objects can be called a set based on the existence of members of the object group and not based on the clarity of the inherent properties of the object being discussed.

The students' concept image also showed that there was a zone of concept image differences between the students' concept image dan the concept definition pada knowledge to be taught dan formal concept definition pada scholarly knowledge. The zone of concept image differences was caused by the inaccuracy of students' conception of set concept. When referring to the teaching and learning process experienced by students, it was found that the inaccuracy of students' conceptions is also caused by the incomplete concept construction process, irregular student learning trajectory, and inaccurate material presentation. In other words, there has been a didactic obstacle to students which has an impact on the zone of concept image difference of students.

### 3.2. Discussion

Set is one of the fundamental objects in mathematics [6]. Therefore, the concept of set from scholarly mathematics was brought into school mathematics. This shows that the concept of set as knowledge to be taught is the result of the transfer of knowledge from scholarly knowledge. This transfer of knowledge occurs under an external didactic transposition and was carried out by the noosphere (curriculum designers and textbook authors) [1,3]. Furthermore, the representation of knowledge to be taught can be seen from the presentation of material in school mathematics textbooks [12].

In school mathematics textbook, a set is defined as well-defined collection of objects. In contrast to scholarly knowledge, in which the definition of a set is still intuitive [13], as knowledge to be taught, the definition of a set is clarified by giving the meaning of the term "well-defined". A collection of objects is called well defined if the object is defined according to properties that have clear measure and do not generate multiple interpretations. In school mathematics textbooks, the form and structure of the set concept was presented with a more concrete formula. It was different from the form and

structure of the concepts presented in scholarly knowledge, which concepts was presented in a more abstract manner [14]. Although the material presentation on the two types of knowledge is different, the transposition of knowledge from scholarly knowledge to knowledge to be taught does not change the meaning of the set conceptually. This shows that there is no concept differences between the set concept in knowledge to be taught and the concept in scholarly knowledge.

The concept of set as knowledge to be taught is then presented in a didactic situation design which includes a series of learning activities, namely observing, questioning, reasoning, and sharing. Then, proceed with practice questions. This learning activity allows for the formation of regular didactic situations as suggested by Brousseau [15], namely didactic situations that allow action situations to occur through observing and questioning activities, formulation situations through reasoning activities, validation situations through sharing activities, and institutionalization situations through activities. work on practice questions. This didactic situation also allows for the formation of a regular learning trajectory for students, so there is no jump in the students' thinking process in the knowledge construction process.

Furthermore, the presentation of the concept set in the school mathematics textbook as a representation of school mathematics curriculum was actually a guide for teachers to teach these concepts in the class. Even so, teachers were still given the opportunity to be able to develop material presentations to become knowledge actually taught based on the conditions of the learning environment of students. However, in the process, the concepts taught in class may differ from the concepts presented in school mathematics textbooks, because each teacher allows them to have a different conception of the concept of set.

As knowledge actually taught, set is a collection of objects that can be grouped according to certain properties or the set is a group of objects that are well defined according to their properties or characters. In general, there is no concept difference between knowledge actually taught and knowledge to be taught. However, in the presentation of the material, the term well-defined has not been clearly defined. On the one hand, well-defined is defined as clarity of size and does not lead to multiple interpretations, but on the other hand, well-defined is defined as the existence of members of a collection of objects. This transfer of knowledge showed a concept differences between the concept of a set as knowledge actually taught and knowledge to be taught due to the inaccuracy of the material presentation.

The transposition on concept of set from knowledge to be taught to knowledge actually taught had an impact to students' concept image. Based on the concept image analysis, students interpreted a collection of objects can be called a set based on the existence of members of the object group and not based on the clarity of the inherent properties of the object being discussed. The students' concept image showed that there was a zone of concept image differences (ZCID) between the students' concept image dan the concept definition pada knowledge to be taught dan formal concept definition pada scholarly knowledge. One of the causes of this ZCID was because the didactic situation that was presented has not accommodated the occurrence of a regular learning trajectory, so that the students' conception of the concept of a set as a result of the student's thinking process was not accurate [16]. This condition results in a didactic barrier to students [17]. Thus, it can be said, ZCID occurs because of didactic obstacle, and this didactic obstacle occurs due to the inaccuracy of the presentation of material during the teaching and learning process.

## 4. Conclusion

Based on the results and discussion, it can be concluded that in school mathematics textbooks, the concept of a set as knowledge to be taught was clearly presented as a well-defined collection of objects, it means that the inherent properties of the object in question can be measured clearly and did not give multiple interpretations. Whereas in the teaching and learning process, the concept of set as knowledge actually taught was presented incompletely. In addition, the didactic situation was presented by teacher in the classroom to emphasize the understanding construction process in determining examples and non-examples of sets and not on the construction of understanding of set

concepts. In contrast to the didactic presentation in textbooks which emphasized the construction process of students' understanding of the set concept itself.

Incomplete set concept presentations and didactic situations that had not accommodated students' thinking process causing students' conception of the set concept is also incomplete, resulting in zone of differences between students' concept images and concept concepts in knowledge to be taught.

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# Junior High School Students' Errors in Solving PISA Open Ended Mathematical Problems Based on Ability Level

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**Abstract**. This study aims to describe the errors made by students in solving open-ended mathematical problems in Program for International Student Assessment type. This study is a descriptive-qualitative. The research subjects were 32 students of grade IX MTs 1 Trenggalek tested with an instrument of open-ended problem that have been validated by validators. The study employed 32 students meanwhile the authors described only 6 students since the data from 6 students have already represented all subjects. The data collected by employing some methods; the open-ended problems test and interview. The analytical framework was developed based on Polya's completion steps. The results of the study are students who have high ability level had type of errors in looking back the solutions obtained. Students who have middle ability level had type of errors in carrying out a plan that has been prepared and errors in looking back the solutions that have been obtained. Students who have low ability level have type errors in understanding the questions, making plans according to the questions, implementing the plan, and looking back the solutions that have been obtained. Finally, researchers concluded that it is good for teachers to employ open-ended Mathematical problems based on real-life in the teaching learning process.

## 1. Introduction

Competition among various countries in facing the developments in the globalization era cannot be denied, especially in the field of education [1], [2]. Education in Indonesia needs an international assessment test that can be used as a benchmark to improve education in this country [3]. Based on the developments in the field of international education there are two international assessment programs; TIMSS (*Trend in International Mathematics and Science Study)* and PISA (Program for International Student Assessment) [4]. TIMSS is an assessment test focusing on students' cognitive abilities, while PISA is a test that assesses students' cognitive and affective abilities such as self-efficacy; students' confidence in his/her own ability to do something [5].

The advantage for Indonesia to take part in PISA is to find out the position of Indonesian students' literacy achievements compared with other countries. On the other hand, it can also find out the factors that affect these achievements [3]. The results of the PISA can be used as a consideration for determining policies as an effort to improve the education sector in facing globalization era [6].

The objects of study on the PISA and TIMSS assessment tests are different. The results of the PISA test are usually used to improve the education quality and policies [7]. The results of PISA test can be used as a psychomotor parameter, and an important knowledge. It is intended to improve the benefits of the knowledge that has been obtained directly by students [8]. Generally, PISA's ability is called literacy ability, which means the ability to solve non-routine problems becomes routine [4]. In the

concept and implementation of the 2013 curriculum, students are required to have critical thinking in solving problems related to the problems given by the teacher or their friends when the learning takes place.

Critical thinking is an important part to improve students' self-literacy skills so that these abilities are needed to create meaningful learning by applying daily problems [9]. However, the result of PISA 2018 test for Indonesian students showed that the ability is still low [10]. Mathematics test scores at PISA 2018 showed that Indonesia was ranked sixty-three out of sixty-nine participants' countries [11][12]. The score obtained by Indonesia in 2018 had decreased including in Mathematics compared to the results of PISA in 2015 [13]. A factor underlying Indonesia's low PISA score is the lack of students' ability to read so that students experienced misunderstanding to the questions. A math problem is called a problem for students if students do not have enough ability to solve the problems in the test given [14].

Mathematical problems can be solved by mathematical problem-solving. Mathematical problem solving is a students' way of thinking, students' analysis, and students' reasoning using initial experience and knowledge related to the problem [15]. Therefore, reasoning and understanding of mathematics are needed to improve the ability in facing problems in daily life. Reasoning and understanding of mathematics are considered very helpful for students in describing, explaining, and predicting events and understanding the rules in daily life [16]. It also becomes the reason why understanding and knowledge about mathematical literacy is considered very important in the students' daily life [17]. An analysis of the students' error needs to be conducted since there are a great number of errors in solving mathematical problems. It can help teachers to improve each student's mathematical understanding concept [18].

Open-ended mathematical problem solving is one of the problems in PISA. Open-ended problems are problems that have more than one solving steps and the correct way of solving [19][20]. Open-ended mathematical problems are problems that have more than one correct answer and more than one set of strategies in getting the solutions [6]. In solving an open-ended problem, students need to set their main goal to emphasize how the steps are, until obtaining the answers [21][22].

The research was conducted in MTsN 1 Trenggalek because the school implemented open-ended problem in Mathematics subject. Beside that, the Mathematics teachers also explained that students' ability levels are varies from the low, middle, and high level. The researchers feel that the required subject can be obtained from this school. Based on interviews with the mathematics teachers in the school, it showed that some students were often easily forgetting some of the materials that have been studied before and still have difficulty in solving open-ended mathematical problems. Open-ended mathematical problem is one aspect of mathematics that can develop useful logical thinking to solve problems [23][24]. The students who made mistakes in solving open-ended problems need to use error analysis in preventing more mistakes in solving identical problems [25][26]. Based on the description above, the purpose of the study is to analyze the types of errors that have been made by students in solving PISA-type open-ended mathematical problems in terms of Polya's solving steps.

## 2. Method

The type of research is descriptive qualitative approach. The researchers try to analyze the results of students' work in analyzing the students' errors in solving PISA-type open-ended mathematical problems based on the students' ability level. The research was conducted at MTs Negeri 1 Trenggalek. The number of subjects was 32 students who had been tested with open-ended mathematical problem. The instruments were developed based on the characteristics of PISA's questions and reviewed by the validators.

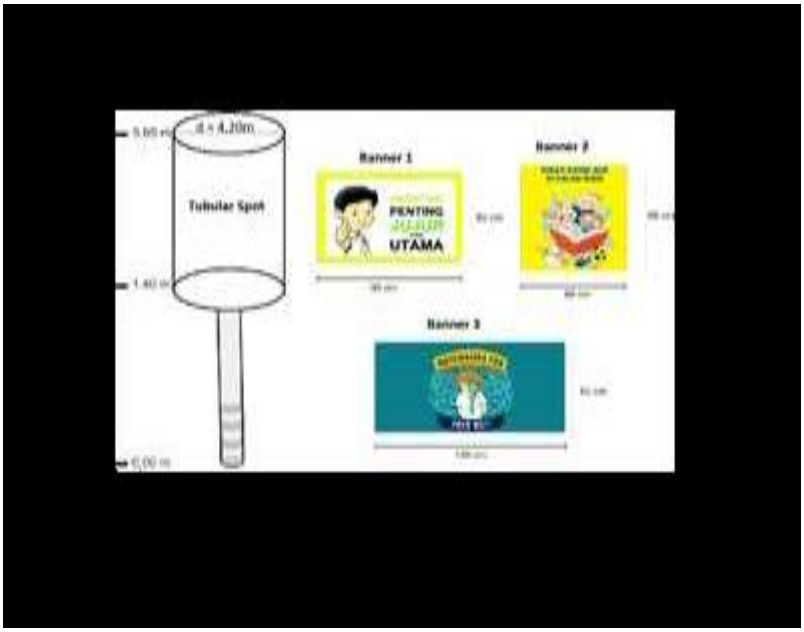


**Figure 1.** Sample of instruments developed based on the characteristics of PISA's questions

From 32 students, 6 students were taken based on their ability level (two students in high ability level, two students in middle ability level and two students in low ability level). The subjects have covered each category of ability levels and been able to be compared. The results of students' interview data were analyzed according to qualitative analysis models. There were three stages including reducing data, presenting data, and verifying data. Researchers used two data collection techniques; tests and interviews with the subjects.

## 3. Finding

The subjects in this study are 6 students. Each subject was coded based on their ability level. The codes of ST1 and ST2 were for high-ability students, SS1 and SS2 codes were for middle-ability students, and codes of SR1 and SR2 were for low-ability students. The test sheets were relating to open-ended mathematical problems.

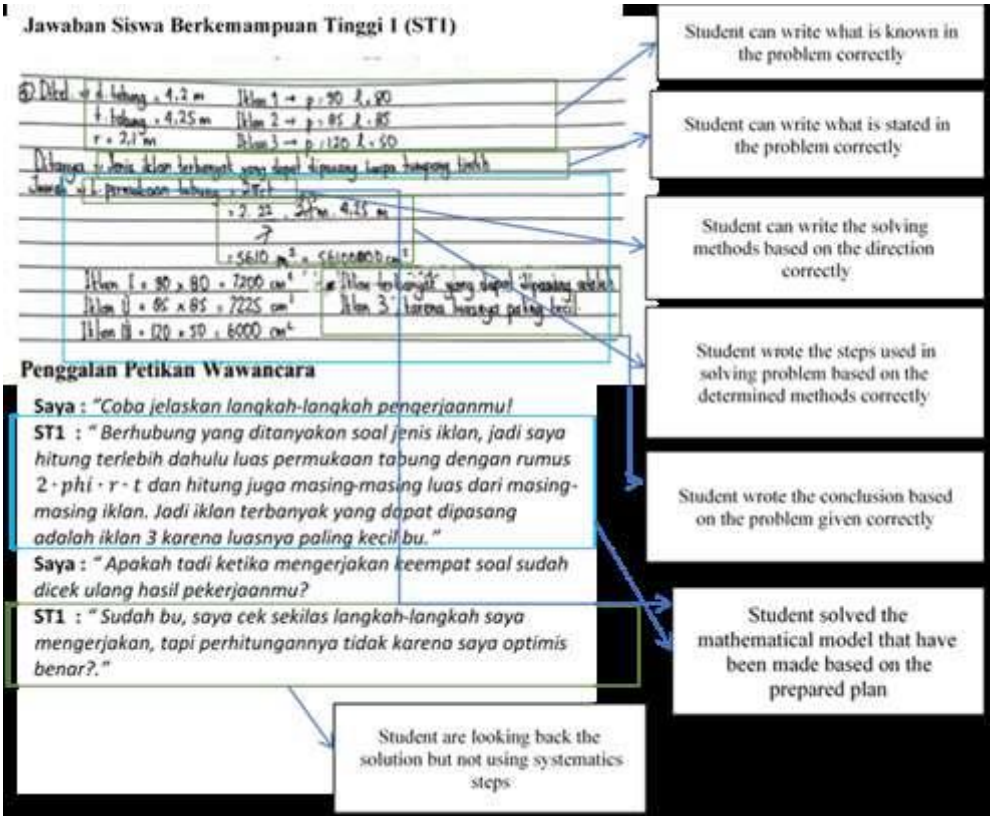


**Figure 2.** The analysis of student's answer and interview of ST1

Figure 2 describes the answer sheet and interview result of ST1. Based on the results of the answers and the results of interviews, ST1 made a few errors. It was written that ST1 can properly write down what was asked and known according to the open-ended mathematical problem that had been given. Students correctly wrote the example variables used in making mathematical models from the data that was known and asked. ST1 wrote a mathematical model in accordance with data that had been determined by the subject. Students wrote the method of solving in accordance with the directions of the open-ended mathematics questions and students wrote the stages that will be used in solving open-ended mathematical problems according to the determined method. The steps of implementing the student's plan also carried out well. However the results of interview found that students made an error when looking back the solution obtained, the reason was based on the results of the interview in which ST1 said that there was no time to look back the solution that had been obtained.

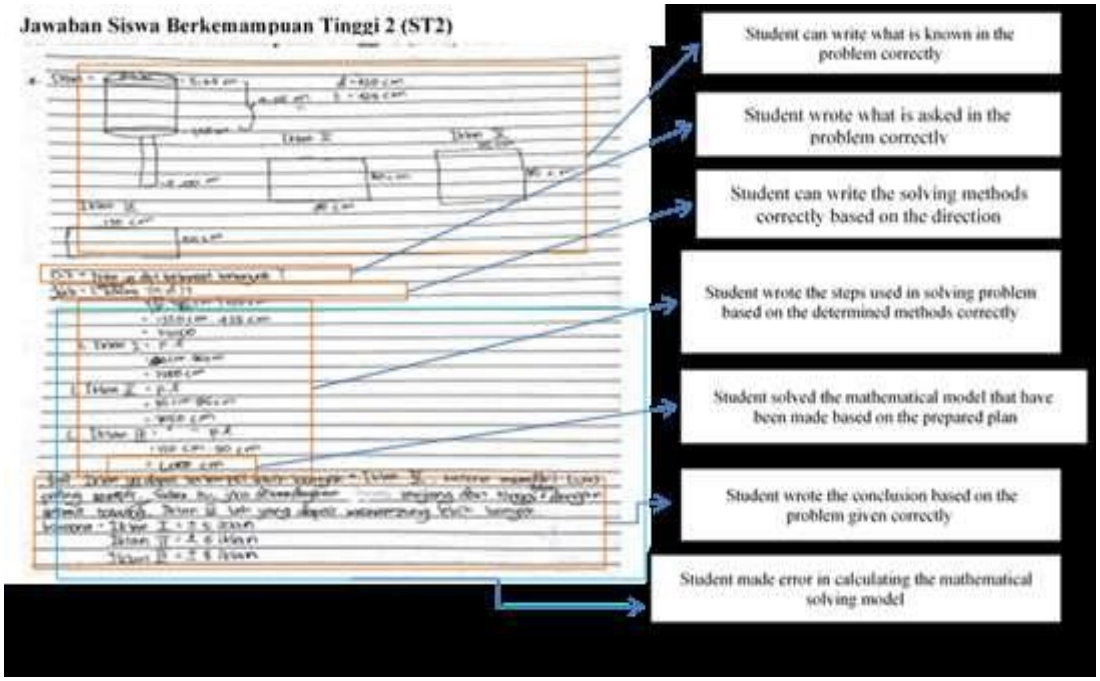


**Figure 3.** The analysis of ST2's answer and interview

Figure 3 reports the answer sheet of ST2. Based on the analysis of the answers and interviews' result of ST2 in Figure 3, errors were found in implementing the plan. Indicator of errors made by the students was making mistakes in calculating the completion of a mathematical model that has been made. Based on the interview results, it can be explained that student also made errors in looking back the solutions that have been obtained. Student's indicators conducted by ST2 was student did not look back the answers obtained and was not re-calculating, so the student found the final answer that was not appropriate because the data used was not appropriate with the problems given.

Based on the analysis of the students' work results and from the results of interviews, for high-ability students, the errors are found in wrongly looking back the solutions that have been obtained. High ability students in solving open-ended mathematical problems are very good by detailing each step of completion so that no step is missed.

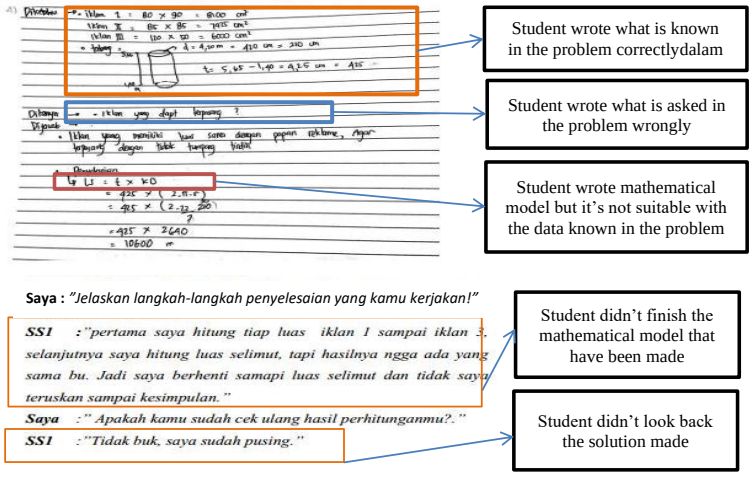


**Figure 4.** The Analysis of SS1's Answer and Interview Result

Figure 4 describes the answer sheet and interview of SS1. It can be described that the type of error was in preparing a plan in which student can write sample variables based on the problem. It meant, students can make mathematical models in accordance with the data that is known and asked on the problem given. Students wrote mathematical models but did not match the data that was known and asked on the open-ended mathematical problems. Students did not write down the stages of completion that will be used in solving the open-ended mathematics problems. The results of student work were also found to be wrong in carrying out the plan. SS1 completed mathematical models that have been made but were not in accordance with the plan drawn up (not based on the method and completion steps used). Student was not doing calculations to complete mathematical models that have been made and student did not write conclusions, the results of the interview showed the type of error that was an error in looking back at the solution obtained. The error indicator is that student did not get the final answer because she did not complete the stages properly.

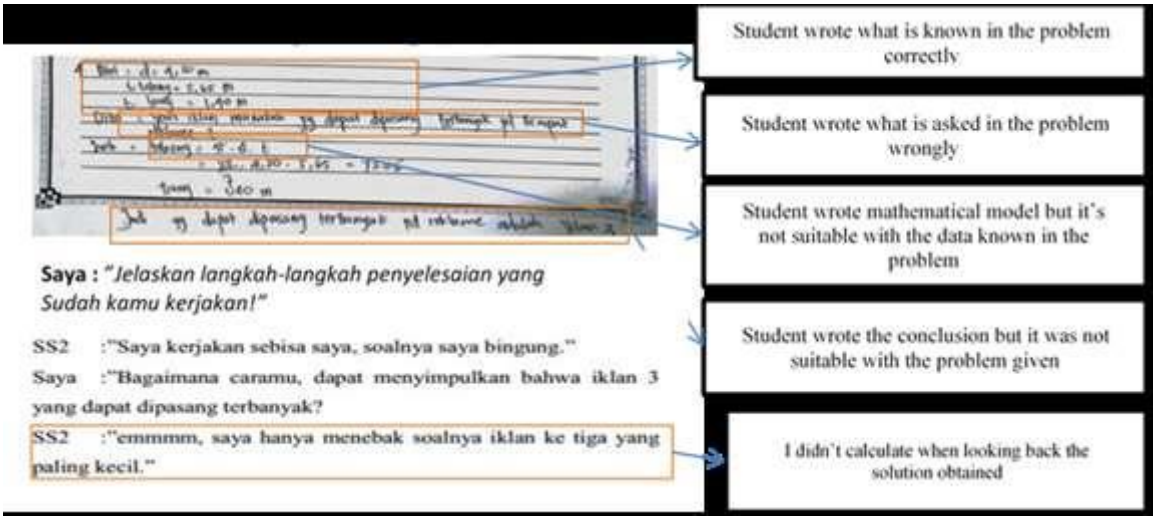


**Figure 5.** The Analysis of SS2's Answer and Interview Result

Figure 5 represents the answer sheet and interview result of SS2. SS2 wrote an example variable that will be used in making mathematical models correctly so that it matched the data that was known and asked. SS2 wrote a mathematical model but did not match the data that was known and asked for an open-ended mathematical problem. The results of SS2 also found errors in carrying out the plan. SS2 completed the mathematical model that had been made but did not fit into the plan drawn up (was not based on the steps and the method of completion used). The SS2's error indicator was that the student got the final answer but did not match the initial data given. Middle ability students, in understanding open-ended mathematical problems, are quite good even though the planning is incorrect. The type found in students' middle ability is errors in making plans and errors in looking back at the solutions that have been obtained.

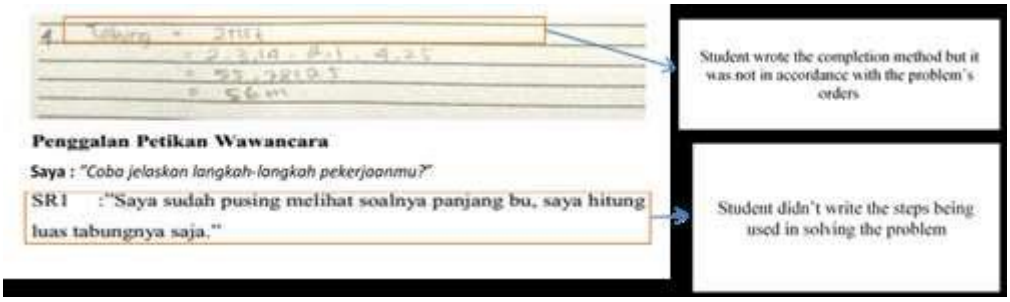


**Figure 6.** The Analysis of SR1's Answer and Interview Result

Figure 6 reports the answer sheet and interview results of SR1. It was found several types of errors. The first error was understanding the open-ended problems that had been given by researchers. Based on the error indicators, students did not write what was known and asked in the open-ended mathematical problem. Then the second error was in compiling a plan that matched the given problem. According to the indicators, students did not write the example variables used in making mathematical models, students did not write mathematical models of open-ended mathematical problems that were given, students wrote solving methods but were not in accordance with the problem's order, and students did not write the appropriate stages to solve open-ended mathematical problems. The third type of error found was an error in carrying out the plan. Students did not complete the mathematical models that had been made and did not write conclusions. The fourth error was the error of looking back at the final answer because students did not understand the problem given, so students did not check the work that has been done.

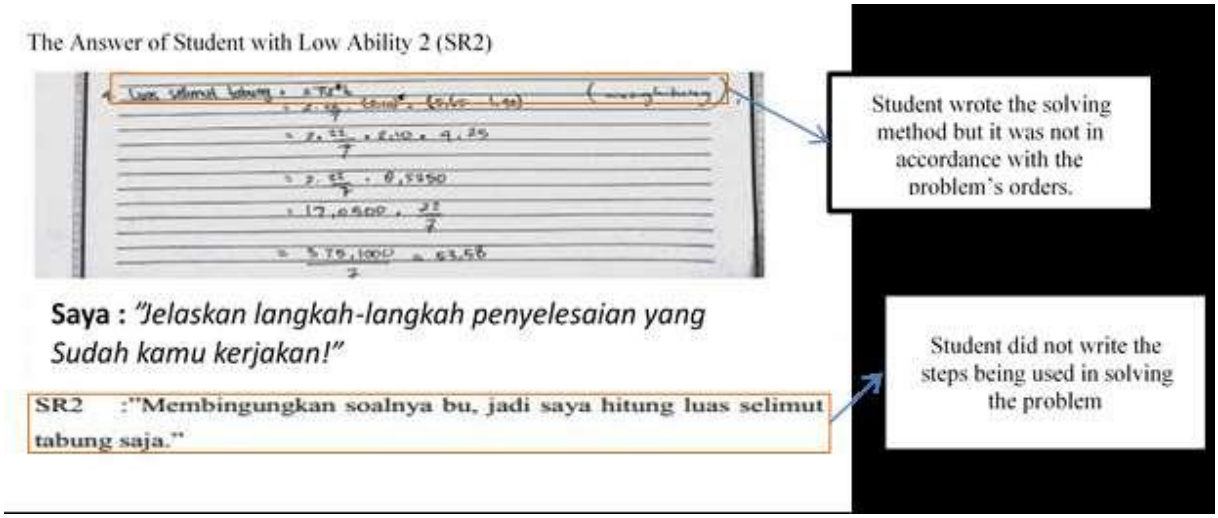


**Figure 7.** The Analysis of SR2's Answer and Interview Result

Figure 7 shows the answer sheet and interview result of SR2. It was found errors just like what SR1 had done. It was found four types of errors; errors in understanding open-ended mathematical problems, error in compiling a plan, error in implementing plans, and errors in looking back the solutions that have been obtained. It can be concluded that students who have low ability cannot understand open-ended mathematical problems so they cannot do the problem-solving stages

## 4. Discussion

The subjects used are two students with low ability, two students with middle ability, and two students with high ability based on the results of the student's initial ability test and are chosen based on the advice of a mathematics teacher in grade IX MTs 1 Trenggalek. Students' errors are seen based on the results of students' open-ended mathematics tests that have been developed according to PISA questions and also from the results of interviews. The process of students' errors in this study is based on the problem-solving steps found by Polya. Polya's problem-solving steps include understanding the problem, compiling the plan, implementing the plan, and looking back at the results of the work.

Students with high-ability ST1 and ST2, based on the analysis of students' work results, are wrong when looking back the solutions that have been obtained. Students with high ability are very good in solving open-ended mathematical problems by detailing each step of completion so that there is no step passed. It is relevant with a statement in which students with good mathematical problem solving means that the students are used to implement the Polya's learning theory [12][27].

Middle ability students who are good enough in comprehending the open-ended mathematical problems even though the planning is not quite right. The error type found in students' ability is the error in compiling plans and error in looking back the solutions that have been obtained. Students who have low ability had four types of errors ,in understanding open-ended mathematical problems, error in compiling plans, error in implementing the plans, and errors in looking back the solutions that have been obtained. Low ability students cannot understand the open-ended mathematical problem so that they cannot conduct the solving problem steps [25].

Finally the study concluded that misunderstanding and errors in compiling plans, changing in the form of mathematical variables (transformation) are more dominant than understanding errors, notation errors, and process errors. The results obtained by many students who have difficulty because PISAs' questions have characteristics in accordance with the real context and require reasoning abilities. [28][29].

## 5. Conclusion

The conclusion based on the data that has been analyzed by the authors; that is the types of errors made by students in solving PISA type open-ended mathematical problems based on the ability level are high ability students are not looking back the results obtained. High ability students in solving open-ended mathematical problems are detailed in each step of the process. Middle ability students are found to have errors in carrying out plans, and errors in looking back the solutions that have been obtained. Students who have low ability make the most errors; those are making wrong plans, carrying out the plan wrongly and looking back the solutions that have been obtained wrongly.

Researchers have some suggestions for teachers; they should often give problems when learning, which sharpened the students' creativity, such as solving open-ended mathematical problems based on real life. Thus, students are expected to be creative and it helps students understand the application of mathematical concepts that have been learned based on real life so that mathematics learning becomes more meaningful because students are expected to be able to understand rather than memorizing formulas.

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