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## Preface

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**240th ECS Meeting** ORLANDO, FL

*Orange County Convention Center* **Oct 10-14, 2021**



Abstract submission deadline extended: April 23rd

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## Preface

The International Conference on Mathematics and Science Education (ICMScE 2020) was a forum for researchers, teachers and graduate students in the field of physics, mathematics and science education to share their current research findings. It was held in Bandung, Indonesia on the 14<sup>th</sup> to 15<sup>th</sup> of July 2020. Due to growing concerns on the COVID-19 pandemic, the conference was held virtually.

The theme of The 2020 ICMScE was “STEM and ESD to Promote Smart and Sustainable Society”. This theme was chosen to showcase the critical roles of mathematics and science education both in the present and in the future to prepare a smart and sustainable society. This conference invited the keynote and invited speakers who are experienced in their fields, so that they can share the latest scientific knowledge to inspire the conference participants. The ICMScE participants came from various universities in Indonesia and abroad, hence it became an ideal opportunity to share knowledge, to exchange ideas and to foster future collaboration between participants.

At the Main Session, four Keynote Speakers had presented their current research, namely Prof Chun-Yen Chang from National Taiwan Normal University, Taiwan; Assoc. Prof. Mageswary Karpurwedan, Ph.D Chemistry Education School of Educational Studies, University Sains Malaysia; Prof Kaur Berinderheet from Nanyang Technological University, Singapore; and Prof. Hiroki Fujii from Okayama University Japan. The Plenary Session presented five Invited Speakers, namely Prof. Nuryani Rustaman (Biology Education), Prof Yaya Sukjaya K, Prof. Ari Widodo (Science Education), Prof Parlindungan and Dr. Ahmad Mudzakir (Chemistry education). At the Parallel Session, a total of 317 presentations were held followed by discussions from presenters, these included four presenters from Malaysia, one presenters from Thailand and one from China.

All papers presented have gone through a rigorous review process. The reviewers involved were 17 experts in the field of physics, mathematics and science education supported by 10 layout editors. The Selected articles were submitted for publication in the IOP Journal of Physics: Conference Series (indexed by Scopus and ISI Thomson Reuters) and PPII affiliated Journal (SINTA Indexed) The remaining articles are to be published in proceedings at the International Conference on Mathematics and Science Education of Universitas Pendidikan Indonesia.

Chairman of the Committee,  
Prof. Yayan Sanjaya



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## Using three-tier test to diagnose students' level of understanding

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# Using three-tier test to diagnose students' level of understanding

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**Abstract.** Assessment activities can help lecturer to understand the strengths and weaknesses experienced by students in learning. By implementing quality assessments and analyzing them to get information about student learning weaknesses, lecturers have a reference to make effective decisions in the learning process. Ability to understand is very important to solve physics problem. Geometric optics is a concept that occur in our daily life. In contrary, it doesn't ensure students have correct concept about geometric optics. The purpose of this study is to diagnose students' level of understanding in geometric optics concept. This study used mixed method design. The sample used in this study was Mechanical Engineering students who took Engineering Physics courses. Based on test result data using paired sample t-test, the average score was obtained from 39.08 to 75.76 ( $p < 0.01$ ). The results of data analysis from the three-tier test diagnostic instrument showed that there are 4 level of students' understanding such as understand, guess, misconception, and don't understand the concept. This study revealed the students' difficulties such as students were not been able to analyze terms and conditions of  $f = \frac{R}{2}$  and light refraction in half covered lens.

## 1. Introduction

Assessment is an inseparable part of learning. In the context of learning, assessment means gathering various information about the process and student learning outcomes in order to determine the decisions that need to be made in learning [1]. Some characteristics of assessment in learning include the following: (1) assessment begins with gathering various information about students in learning; (2) analyzing and interpreting the data and information that has been collected; (3) interpretation results in decisions about learning; (4) there is a follow up on the decision made; (5) assessment is carried out on an ongoing basis [2]. One way to identify student misconceptions is by conducting a diagnostic assessment. Diagnostic assessment is used to determine the strengths and weaknesses of students in learning a concept which is then carried out feedback to student and lecturer [3]. Diagnostic assessment also focuses on the difficulties experienced by students in learning a concept. Diagnostic assessment results can be used as a basis for determining appropriate actions to maximize learning process.

Feedback is an inseparable part of the assessment. Feedback should be an alternative solution for students who do not understand the concept [4]. The meaningfulness of feedback in learning activities will be realized if the lecturer has understood the meaning of feedback, feedback functions, types of feedback, and who should be given fast and appropriate feedback during the learning activities carried out.



Understanding concept is one of important aspects in the learning process, so it can be applied to explain the phenomenon that occurs in daily life. Although today's learning goals of physics are developed until high order thinking skills, but ability to understand the concept of physics is very crucial. A good understanding of students' concepts is needed to solve physics problems. However, the weakness of the student conceptual framework can be a major obstacle to solve problem [5]. Many studies have shown that although students can solve quantitative problems by incorporating values into mathematic equations, students may not build the skills needed to transfer understanding and solve more complex problems.

The aims of this study is to diagnose students' understanding. The result of assessment will be categorized into 4 level of understanding ( understanding, having misconception, guessing, and don't understand the concept). The focus of the topic in this research is about Geometric Optics based on several reasons as follows: (1) The concepts in Geometric Optics are concepts that are closely related to daily life; (2) The concepts in Geometric Optics are studied at various levels of education from elementary to higher education; (3) Educational research indicates that students have different conceptions of Geometric Optics that are scientifically different.

## 2. Methods

This research was implemented mixed method embedded experimental design [6]. This research was conducted at Universitas Nusantara PGRI Kediri. The subject was mechanical engineering student who took Engineering Physics course in 2019/2020 academic year. The sample consists of 84 students. The sample selection was based on heterogeneous student ability. The data of this study are observational students' understanding in pre-test and post-test, and interviews. All of data retrieval is done online. Diagnostic assessment collection is done by using a website that was developed previously (article about it will be presented separately). Data were analyzed quantitatively are score of students' understanding by paired sample t-test, and level of students' level of understanding by a rubric. Data were analyzed qualitatively are interviews.

Three-tier diagnostic instrument consists of 10 questions. Each question consists of three levels. At the first level is the choice of ordinary answers, the second level is the choice of reasons, and the third level is the level of confidence in the answers and reasons. Eight possible combinations of student answers and answer categorization guidelines for the three tier concept mastery questions can be seen in table below.

**Table 1.** The three-tier test diagnostic rubric

First Tier	Second Tier	Third Tier	Category
Correct	Correct	Confident	Understand/master the concept
Correct	Wrong	Confident	Misconception
Wrong	Correct	Confident	Misconception
Wrong	Wrong	Confident	Misconception
Correct	Correct	Not Confident	Guess the the concept
Correct	Wrong	Not Confident	Don't understand the concept
Wrong	Correct	Not Confident	Don't understand the concept
Wrong	Wrong	Not Confident	Don't understand the concept

The results of the pre-test and post-test score provide information on students' level of understanding, while the reasons for the students' answers provide deeper information about the conceptions of the students. Interviews were conducted to confirm the reasons for the students' answers that were not clear. Data validation using expert judgement, data triangulation, and SPSS. Expert judgement was used to validate the test items and students' understanding rubric. Data triangulation was included interview, test, and observation. SPSS was used to calculate items validity, normality, and effect size.

### 3. Result and Discussion

Quantitative data of students' understanding was obtained by students through pre-test and post-test. Descriptive statistics of students' pre-test and post-test scores are presented in Table 2.

**Table 2.** Descriptive statistics of students' pre-test and post-test scores

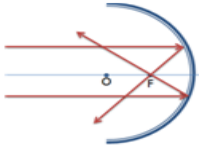
	N	Min	Max	Mean	Std. Dev	Skewness	
						Statistic	Std. Error
Pre-test	84	30	55	39,08	8,69	0,41	0,26
Post-test	84	50	90	75,76	6,39	-0,38	0,26

According to Table 2, the data is normally distributed because the skewness is -1 until +1 [7]. If the pre-test and post-test scores are normally distributed then it can be tested by paired sample t-test. The paired sample t-test results obtained  $t(83) = 35.85$  with a significance value of 0.00. The significance value is less than 0.05 so it can be concluded that the difference in pre-test and post-test scores is significant. The post-test score is greater than the pre-test so that the use of diagnostic assessments can improve students' understanding. According to three-tier test, the result can diagnose students' level of understanding. The following is an example of diagnostic assessment result.

#### 3.1. Terms and conditions of $f = \frac{R}{2}$

Students' understanding about terms and conditions of  $f = \frac{R}{2}$  was explored through question below.

**Question:**  
In concave mirror, the relationship  $f = \frac{R}{2}$  applies. Are all the rays coming in parallel to the main axis reflected through the focus point (F)?



I. Choose the best answer for the question above

- Yes
- No, only applies if the radius of curvature of the mirror is very small
- No, only applies if the radius of curvature of the mirror is very large
- No, it only applies to rays that are close to the main axis

II. Choose your reason

- Rays come parallel to the main axis always reflected through focus because it is one of special ray
- If the rays come parallel to the main axis which is spread far away the main axis will cut off the main axis at  $f = \frac{R}{2}$
- Concave mirror is converging rays, so all rays that come parallel to the main axis reflected through the focal point

III. Are you sure about the answer you've chosen?

- Yes
- No

**Figure 1.** Three-tier test about terms and condition of  $f = \frac{R}{2}$

Based on the question above, the feedback gives a diagnostic assessment that indicates students' level of understanding. It will be presented in Table 3.

**Table 3.** Students' level of understanding about terms and condition of  $f = \frac{R}{2}$ 

Level of understanding	Pre-test	Post-test
Understand	45.24%	61.9%
Misconception	32.14%	19.05%
Guess the concept	15.48%	14.29%
Don't understand	7.14%	4.76%

According to Table 3, students' level of understanding is change to a better understanding. Students assume that the focal length is always half of the radius curvature of the mirror. At the time of the pre-test, all students have that conception all the rays coming in parallel to the main axis are reflected through the focal point because is one special sound of a concave mirror and is not formed shadow if it is not reflected through the focus point. Incorrect conception of the relationship  $f = \frac{R}{2}$  applies to all conditions indicates that students do not understand correctly about the rays paraksial and the consequences.

Based on interviews with physics teacher in Junior and Senior High School, the teacher did not explain about the paraxial rays and the consequences. This leads to the fact that neither teachers nor students understand that the use of special rays and  $f = \frac{R}{2}$  relationships only apply to partial rays. Not all incoming rays parallel to the principal axis are reflected at  $f = \frac{R}{2}$ . The rays that spread far away with the main axis do not intersect the major axis at  $f = \frac{R}{2}$ . The rays that spread close to the main axis or paraxial rays intersect the main axis exactly at  $f = \frac{R}{2}$ . The incident rays formed by the paraxial rays is  $\pm 10^\circ$ .

### 3.2. Light refraction in half covered lens

Students' understanding about light refraction was explored through question below.

**Question:**  
An optical system consists of a candle, convex lens, and screen. Candles are placed at point O so as to produce a real and sharp image when the screen is placed at point I as shown in Figure (a). If half the lens is covered with an opaque object (Figure b), then what is captured on the screen is ...

**Figure (a)** **Figure (b)**

- I. Choose the best answer for the question above
  - a) No candle shadow is formed
  - b) The candle flame is still formed but the lower end is cut off
  - c) Complete candle shadow is still formed, but dimmer than before
  - d) Complete candle shadows is formed and remain sharp
- II. Choose your reason
  - a) No candle shadow is formed due to formation shadows can occur if there is intersection of 2 special rays
  - b) No candle shadow is formed because of some lenses covered by objects that are not translucent
  - c) The shadow of the candle is cut off because part of the lens is covered by an opaque object
  - d) Complete candle shadow is still formed because the other rays that are not special rays are still refracted to the part of the lens that is not covered by a translucent object light.
- III. Are you sure about the answer you've chosen?
  - a) Yes
  - b) No

**Figure 2.** Three-tier test about light refraction

Based on the question above, the feedback gives a diagnostic assessment that indicates students' level of understanding. It will be presented in Table 4.

**Table 4.** Students' level of understanding about terms and condition of  $f = \frac{R}{2}$

Level of understanding	Pre-test	Post-test
Understand	19.05%	58.33%
Misconception	42.85%	21.43%
Guess the concept	16.67%	11.91%
Don't understand	21.43%	8.33%

According to Table 4, students still have misconception that images can only be formed by special rays. In addition, students came up with the idea that with partially covering the lens with an opaque object so the image does not formed or partially cut off. But, in the post-test this students has understood the concept that image remain formed and dim even though partially the lens is partially closed by an opaque object. In interview that conducted further, however there are still students assume that by closing two special rays then a part the image will disappear and even the image will not form. In general, students draw a image-forming beam diagram of a convex lens using special rays. Most students think that image is only produced by special rays. This causes students to have an understanding that other rays that are not special do not contribute to producing image. Students assume that the image will be cut off not even formed if the lens is partially closed. This is because the special rays are blocked by transparent objects so they can not be biased. When the convex lens is partially closed by a transparent object, the image is still formed by all the rays of the object that is about the lens. The function of special rays in the formation of image is to help find the position of the image. Furthermore, all rays of the object are refracted to the point of the image. Images are formed by all the rays of the object that is about the lens. Although half of the convex lens is closed the image remains intact but dimmer. The dimmer image is caused because not all rays come on the lens surface.

The wrong conception students have that partially closing the lens will formed image is cut off or not formed shadows in line with the results of research conducted by [8][9]. Students do not realize that the image is still formed by all the rays from objects that hit the lens. Function special rays in the formation of image only help find image position. Next, all the rays from the object will be refracted to the point the image. Image is formed by all the rays of the objects that hit lens. Even though half the convex lens is closed, a permanent image is formed whole but fainter. Fainter image are caused by not all rays come on the surface of the lens.

#### 4. Conclusion

According to the analysis, we've found that students have 4 level of understanding in all question that is understand, guess, misconception, and don't understand the concept. This study revealed the students' difficulties such as students were not been able to analyze terms and conditions of  $f = \frac{R}{2}$  and light refraction in half covered lens. These difficulties must be addressed immediately by teacher. One of the solution to remediate the students' conception is emphasize the basic concept of geometric optics and its implication. It was clear from the literature that geometric optic is one of difficult concept to understand and it was proved in this study. Building concepts through designing the appropriate learning can strengthen understanding of basic concepts and applied situations.

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