PAPER · OPEN ACCESS

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

View the article online for updates and enhancements.

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

Y S Pramesti*, H Mahmudi, and I Setyowidodo

Program Studi Teknik Mesin, Universitas Nusantara PGRI Kediri, Jl. KH. Ahmad Dahlan No. 76, Kediri 64112, Indonesia

*yasintasindy@gmail.com

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 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.

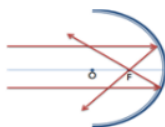**Table 2.** Descriptive statistics of students' pre-test and post-test scores

	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 il +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 ue 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.

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°.

3.2. Light refraction in half covered lens
Students' understanding about light refraction was explored through question below.

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.

5. References
[1] Anderson LW 2003 *Classroom assessment: Enhancing the quality of teacher decision making* Routledge.
[2] Kusairi S 2012 Analisis asesmen formatif fisika sma berbantuan komputer *Jurnal Penelitian dan Evaluasi Pendidikan* 16 68-87.
[3] Zhao Z 2013 An overview of studies on diagnostic testing and its implications for the development of diagnostic speaking test *International journal of English linguistics* **3** 1 41.

[4] Stull JC, Majerich DM, Bernacki ML, Jansen Varnum S, Ducette JP 2011 The effects of formative assessment pre-lecture online chapter quizzes and student-initiated inquiries to the instructor on academic achievement *Educational Research and Evaluation* **17** 4 253-62.

[5] Hegde B, Meera BN 2012 How do they solve it? An insight into the learner's approach to the mechanism of physics problem solving *Physical Review Special Topics-Physics Education Research* 8 1 010109.

[6] Cresswell W. John 2013 *Research Desaign. Qualitative, Quantitative and Mixed Methods Approaches*, Universitas Nebraska, Lincoln: Sage Publications

[7] Morgan GA, Leech NL, Gloeckner GW, Barrett KC 2004 *SPSS for introductory statistics: Use and Interpretation* Psychology Press.

[8] Goldring H, Osborne J 1994 Students' difficulties with energy and related concepts. *Physics education* 29 1 26.

[9] Galili I, Hazan A 2000 Learners' knowledge in optics: interpretation, structure and analysis *International Journal of Science Education* **22** 1 57-88.

Introducing Life Skills Through Project-Based Learning in Speaking for Informal Communication Course at University of Nusantara PGRI Kediri

ORIGINALITY REPORT

16%

SIMILARITY INDEX

PRIMARY SOURCES

1   kclpure.kcl.ac.uk
Internet
57 words — 2%

2   Siti N.H. Hadie, Anna A. Simok, Shamsi A. Shamsuddin, Jamilah A. Mohammad. "Determining the impact of pre-lecture educational video on comprehension of a difficult gross anatomy lecture", Journal of Taibah University Medical Sciences, 2019
Crossref
34 words — 1%

3   journal.uwks.ac.id
Internet
33 words — 1%

4   www.ugr.es
Internet
28 words — 1%

5   journal.um.ac.id
Internet
22 words — 1%

6   repository.unikom.ac.id
Internet
19 words — 1%

7   www.omicsonline.com
Internet
18 words — 1%

8   journal2.um.ac.id
Internet
18 words — 1%

9   jela.jp
Internet
18 words — 1%

10 textarchive.ru
Internet
17 words — 1%

11 2019.fmgtegitimikongresi.com
Internet
16 words — 1%

12 repositori.uji.es
Internet
14 words — 1%

13 ejournal.unwaha.ac.id
Internet
14 words — 1%

14 ajis.fisip.unand.ac.id
Internet
13 words — < 1%

15 www.mnhawkeye.com
Internet
13 words — < 1%

16 Nuri Balta, Mervi Asikainen. "Introductory students' attitudes and approaches to Physics problem solving: Major, achievement level and gender differences", Journal of Technology and Science Education, 2019
Crossref
13 words — < 1%

17 sinta2.ristekdikti.go.id
Internet
11 words — < 1%

18 dtpr.lib.athabascau.ca
Internet
10 words — < 1%

19 fr.slideshare.net
Internet
10 words — < 1%

20 Supriyono Koes-H, Muhardjito, Charisma P. Wijaya. "Scaffolding for solving problem in static fluid: A case study", AIP Publishing, 2018
Crossref
9 words — < 1%

21 www.jppipa.unram.ac.id
Internet
9 words — < 1%

22 Zhen Chen, Yi Liu, Lin Wang, Yanxia Su. "VOCs pollution characteristics and potential of ozone generation in Kaifeng City", IOP Conference Series: Earth and Environmental Science, 2021
Crossref

9 words — < 1%

23 www.tc.columbia.edu
Internet

8 words — < 1%

24 researchonline.jcu.edu.au
Internet

7 words — < 1%

25 Cooper, Jonathon A.. "Understanding and Using Statistics for Criminology and Criminal Justice", Oxford University Press
Publications

7 words — < 1%

26 repository.uin-suska.ac.id
Internet

6 words — < 1%