Available online at http://journal.um.ac.id/index.php/jps
ISSN: 2442-3904 (electronic)
DOAJ-SHERPA/RoMEO-Google Scholar-SINTA 3

Jurnal Pendidikan Sains
Volume 9, Number 3, September 2021, pp. 73–78

PROFILE OF PROBLEM-SOLVING ABILITY OF HIGH SCHOOL STUDENTS WITH DIFFERENT CLASS CLASSIFICATIONS ON LIGHT WAVE LEARNING

Ahmad Nasich Luthfi[a,1,*], **Edi Supriana**[a,2], **Supriyono Koes Handayanto**[a,3]
[a] *Physics Education, Universitas Negeri Malang, Jl. Semarang No.5 Malang, Malang 65145, Indonesia*
[1] *nasich28luthfy@gmail.com**; [2] *edi.supriana.fmipa@um.ac.id*; [3] *supriyono.koeshandayanto.fmipa@um.ac.id*
*Corresponding author

ARTICLE INFO

Article history:

Received 12/02/2021
Approved 14/03/2021

Keywords:
Problem solving ability
High school student
light wave

ABSTRACT

Abstract: This study aims to compare the problem-solving abilities of high school students with different class classifications on light waves. The research uses a survey method with the subject of class XI students as many as 123 high school students in the Mojokerto area. The t instrument used is in the form of k 6 questions about the ability to solve the problem of light waves. The students' approaches to the questions are categorized into five , namely: scientific approach, plug & chug structured and unstructured, memory-based approach and no clear approach . The results of the study show that students' problem-solving abilities are in the structured, unstructured Plug & Clug approach and the memory-based approach. This shows that students are still in the novice group. The highest percentage of problem-solving abilities are students of class XI and the lowest are students of class XI. This research needs to be followed up with various efforts to overcome the low problem solving ability of students in physics learning.

INTRODUCTION

The study of the properties of light waves, including light interference, makes for fascinating physics topics. Interference with light is a difficult topic in physics for students (Sutopo, 2011) Conceptual understanding is where students face the most difficulty (Imiati, Purwaningsih, & Sulur, 2016). Students must understand the fundamental principles of light waves since these fundamental concepts will be needed to study advanced physics subjects such as spectroscopy, seismology, meteorology, and others (Sutopo, 2016). However, researchers are conducting little research on light waves at present, therefore a deeper grasp of light wave concepts is required (Sutopo, 2016).

Students' mastery of topics can be determined by their problem-solving skills. This is because manipulating equations is insufficient to solve problems; one must also understand the underlying concepts and principles (Docktor et al., 2015). Problem solving is a preferred activity for assisting students in acquiring concepts and is seen as a great indication of conceptual understanding (Butler & Coleoni, 2016). (Docktor et al., 2016) Physicists employ problem solving to teach physics curriculum and assess whether students have mastered the subject that has been studied.

Prior analysis of the learning and mastery difficulties of high school pupils in physics concepts. The findings indicate that high school students find it challenging to learn wave material (Istyowati, Kusairi, & Handayanto, 2017). Simamora's research demonstrates, however, that students' problem-solving skills do not improve (Simamora et al., 2016). The outcomes require that students become accustomed to the methodical application of problem-solving abilities. Azka (2017) conducted a comparative study of problem-solving abilities, however the current study intends to determine the difference in the degree of problem-solving ability on trigonometric material for class X students through the application of pre and post solution posing learning methods. On light wave materials, there has never been any research comparing the problem-solving skills of pupils from diverse class backgrounds.

Presently, there is no research on the impact of the 2013 curriculum on students' problem-solving skills in schools implementing the 2013 curriculum. (Kemendikbud, n.d.) On the basis of this argument, research is required to determine whether or not school-based learning can train kids' problem-solving skills, and it is also essential to determine how problem-solving skills develop among students dependent on their class standing.

The purpose of this study is to compare the problem-solving skills of students from various class classifications with regards to light-wave materials. This comparison was conducted to determine how the problem-solving skills of high school students vary by class and to determine whether the learning conducted was able to train students' problem-solving skills, so that educators and education policymakers can prepare higher-quality physics education in the future.

METHOD

This research was a survey research that aims to explain certain aspects or characteristics of a population and test hypotheses about the nature of relationships in a population. The essence of survey research is to ask individuals on a topic and then describe their responses (Jackson, 2012) . The research subjects were high school students in the Pacet area, Mojokerto. There were 32 students in class XI IPA-1. On average, students are in the lower middle class economy. Previously, students had never received a problem solving ability test.

The instrument used in this study was a test consisting of 6 questions which functioned as a measure of the student's problem-solving ability variable. The problem solving ability category of students and their assessment rubrics in this study refers to the problem solving ability category and the assessment rubric developed by Wash (2007) , Hulll (2013) and Docktor (2016) . The instrument reliability value was 0.83. The instrument was declared valid and suitable for use in the field by the validator .

Data collection was carried out by giving a problem solving ability test . The indicators used are cognitive domain indicators which are adjusted to the syllabus for physics subjects for XI Grade.

Table 1. Indicators of Light Waves for each Item

No.	Indicator	Question Number
1.	Solve light wave problems regarding internal interference everyday life	1, 2, 3, 6
2.	Solve light wave problems regarding diffraction in everyday life	4, 5

Responses from students are differentiated based on the category of analysis of problem-solving abilities. Analysis of the categories of student answers can be seen in table 2 (Walsh et al., 2007) .

Table 2 . Category Answers for Data Processing Problem Solving Ability

Category		Criteria for Problem Solving Approach
Scientific Approach		• Analyzing the problem qualitatively • Plan and carry out solutions systematically based on qualitative analysis • Solution refers to the concept • Evaluating solutions
Plug & Chug	Structured	• Analyze the problem qualitatively based on the required formula • Planning and implementing solutions based on the variables asked • Solution refers to the concept • Evaluating solutions
	Unstructured	• Analyze the problem based on the required variables • Try or choose a formula based on a variable • Variable refers to the concept • Do not evaluate
Memory Based Approach		• Analyze problems based on examples or prior knowledge • Try to adjust variables based on examples or knowledge previously • Do not evaluate
No Clear Approach		• Analyze the problem based on the given variables • Try to use variables in an obscure way or not using any variables • Not checking

Source: (Walsh et al., 2007)

Data analysis was carried out by calculating the percentage of each category using equation (1) below (Amalia, Sinaga, Sari, & Saepuzaman, 2016) :

$$P = \frac{f}{N} \times 100\% \quad (1)$$

Information:
P= percentage of each category
f= the number of students in each category
N = the total number of students who are used as research subjects

RESULTS

Based on data analysis regarding the comparison of problem solving abilities of students with different class classifications, the percentage of each category is obtained as shown in Table 3.

Table 3. Results of the Problem Solving Ability Test on Light Wave Materials

No	Draft	Category (%)																			
		Scientific Approach				*Plug & Chug*								*Memory Based Approach*				*No Clear Approach*			
						Structured				Unstructured											
IPA Class Classification		1	2	4	5	1	2	4	5	1	2	4	5	1	2	4	5	1	2	4	5
1.	Light and dark pattern distance interference	0	0	0	0	56	16	57	10	41	78	23	33	3	3	13	27	0	3	7	30
2.	Interference events	0	0	0	0	56	72	10	3	3	19	3	3	38	6	40	30	3	3	47	64
3.	Wide spectrum interference pattern	0	0	0	0	72	36	3	30	3	39	94	7	19	10	0	57	6	15	3	6
4.	diffraction event	0	0	0	0	3	97	0	3	88	3	0	23	3	0	17	17	6	0	83	57
5.	Minimum slit width of light	0	0	0	0	13	94	3	33	19	3	0	66	59	3	94	0	9	0	3	0
6.	Minimum thickness of the green light film	0	0	0	0	41	13	17	27	3	87	0	63	56	0	80	10	0	0	3	0
Average		0	0	0	0	40	54	15	18	26	38	20	33	30	4	41	24	4	15	24	26

Table 3 displays the results of a test in which problem-solving ability questions were included. According to the average results, the majority of class XI pupils are enrolled in the structured Plug & Clug technique, constituting 40% and 54%, respectively. Approximately 41% of class XI IPA-4 students are enrolled in the memory-based technique. The majority of class XI IPA-5 students, 33 percent, are enrolled in the unstructured Plug & Clug technique. In response to question number 2 pertaining to interference incidents in daily life, the majority of class XI students choose the no clear answer, with 47 percent and 64 percent, respectively. Similar to question 4, discussing diffraction events in everyday life, the majority of class XI students (83 percent and 57 percent, respectively) choose the no clear approach. These are the second and fourth problem-solving questions employed in this study.

1. *Monochromatic light was passed through two slits 0.1 mm apart. The interference pattern is captured with a screen that is 1.2 m from the slot. If the wavelength of light is 5,000 Å, determine:*
   a. *Distance of the 2nd light band from the center light*
   b. *The distance of the 2nd dark band from the center light*
   c. *Distance between the two bands (2nd light and 2nd dark)*

4. *Luthfia conducted an experiment to determine the wavelength of a ray using a diffraction grating. The light source, grid, and screen are set at a fixed fixed distance. First of all, Luthfia used purple light ($\lambda_u = 400\ nm$) as a reference. In fact, the distance of the first band of purple light from the center light is 3 mm. Next, Luthfia uses the rays which she will determine the wavelength. In fact, the distance of the first band of light from the center light is 4.5 mm. Determine the wavelength of light that Luthfia measured.*

In questions 2 and 4, the majority of eleventh-grade students select the no clear answer option. Students can only record the known variables of the problem at hand. In addition, some students attempted to identify the necessary variables to answer the problem, but their efforts were imperfect. Students have been unable to communicate problem-solving strategies, hence the ultimate product of problem-solving cannot be appraised. In contrast, the majority of class XI students utilize the unstructured and structured Plug & Clug strategies for questions 2 and 4. In accordance with this methodology, students examine problems by transforming variables from phrases into physical symbols. Students understand the problem through problem-based questions. Students can decide which variables must be solved by referencing previously learned principles. Students are able to articulate problem-solving strategies thus the final outcome of problem-solving may be evaluated.

The results of the solving ability test are then graphed by percentage based on categories. The percentage of students' categories on the concept of interference and diffraction is shown in Fig 1

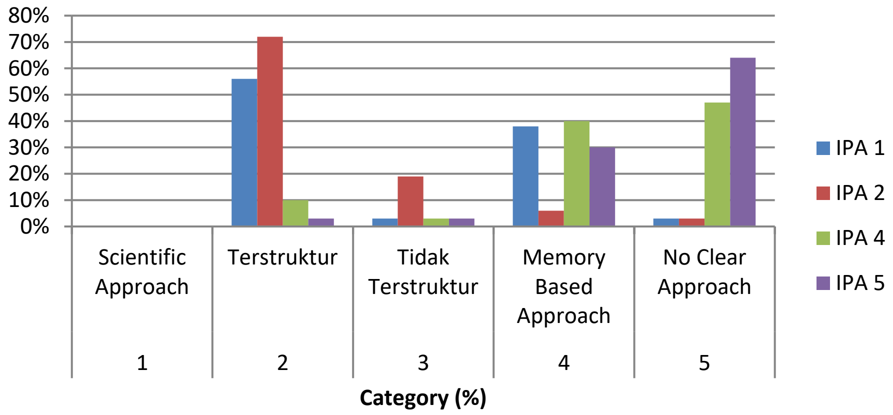

Figure 1. The Percentage of Student Categories on the Concept of Interference

Based on Figure 1, it is evident that the majority of grade XI students' problem-solving skills for question number 2 on the idea of interference are in the structured Plug & Clug technique, with 56 percent and 72 percent, respectively. In other words, the degree of problem-solving ability of grade XI students is superior to that of grade XI students, as the proportion of grade XI IPA-2 students is more than that of grade XI students. As seen in Figure 1, the majority of class XI students, 47 percent, are in the no clear approach group, while 64 percent are in the no clear approach group. Students in class XI IPA-4 have a higher degree of problem-solving ability than students in class XI IPA-5, given that the percentage of students in class XI IPA-4 is smaller than the percentage of students in class XI IPA-5. Figure 2 depicts the percentage of student categories who understand the concept of diffraction.

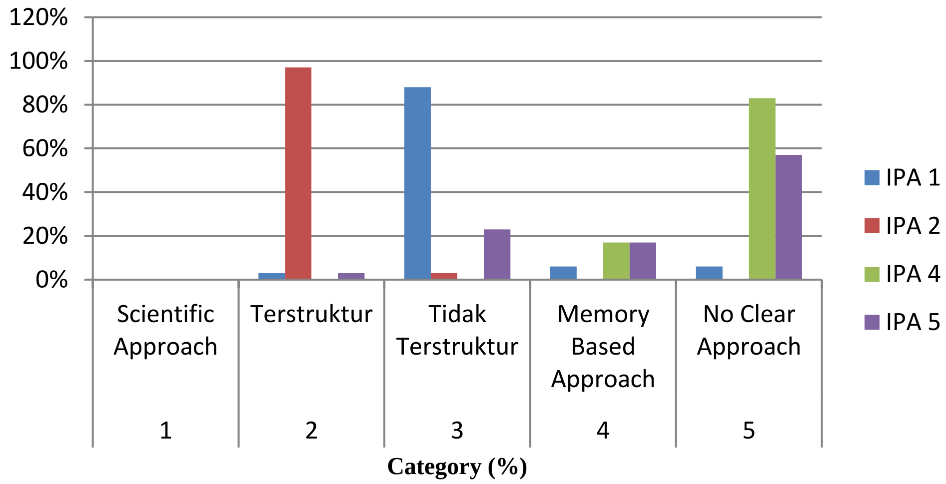

Figure 2. The Percentage of Student Categories on the Concept of Diffraction

Figure 2 indicates that 88 percent of the responses to question number 4 discussing the idea of diffraction are unstructured Plug & Clug responses. 97 percent of class XI IPA-2 implementations utilize the structured Plug & Clug technique. Figure 2 indicates that the majority of class XI IPA-4 and IPA-5 students (83 percent and 57 percent, respectively) fall into the category of 'no clear approach'

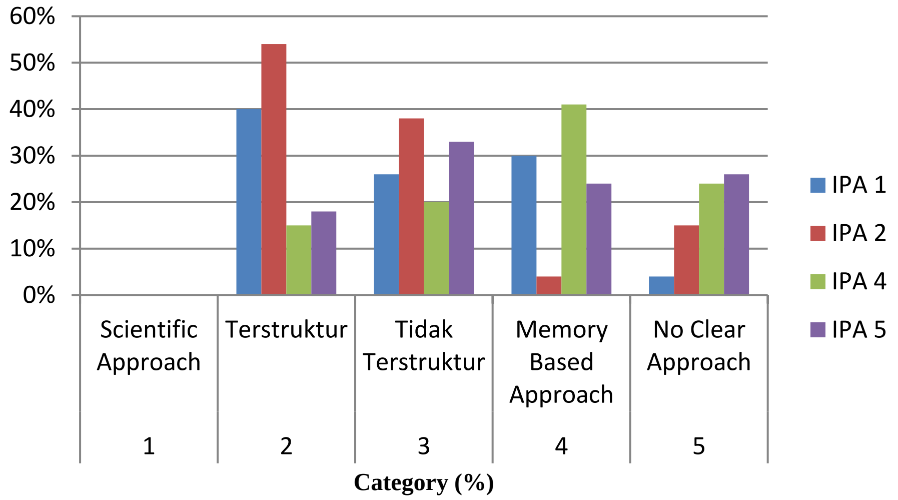

Figure 3. The Percentage of Category of Problem Solving Ability in Class XI IPA-1, 2, 4 and 5 Class Students

A graph depicting the average percentage of class XI students with problem-solving skills with the idea of light wave topic. The category with the highest percentage of students' problem-solving abilities is the structured Plug & Clug approach category, which contains 54 percent of students. This is followed by the structured Plug & Clug approach category, which contains 40 percent of students, the unstructured Plug & Clug approach category, which contains 33 percent of students in class XI IPA-5, and the memory-based approach category, which contains 41 percent of students in class XI IPA-4.

DISCUSSION

On light waves, the problem-solving abilities of eleventh graders is still inadequate. Based on a review of student responses, it has been determined that students' problem-solving skills are subpar since they are not accustomed to working with analytical inquiries in the form of descriptions. According to the research by Simamora et al. (2016), the element that contributes to students' poor problem-solving skills is the use of only quantitative and non-contextual questions in the classroom. Students receive learning that is dominated by a summary of the content and a collection of formulas (Ni'mah, Kusairi, & Supriana, 2019). This leads to a lack of mastery of physics material. In addition, the belief that learning physics is difficult contributes to the low learning activity of students (Simamora et al., 2016).

Class XI IPA-2 students had the largest proportion of problem-solving skills, whereas class XI IPA-4 students had the lowest proportion. According to Mustika (2014), students in the highest class categorization are not necessarily proficient problem solvers.

The problem-solving proficiency of the students in this study remains at the novice level. An expert can combine physics problems based on comparable principles and apply a conceptual approach for solving difficulties, whereas a novice will rely on surface features (object, context, and quality) (Mestre et al., 2012).

When compared to research conducted by Afifah (2019), which is the same, students' problem-solving capacity is still in the novice category, where they employ a structured, unstructured Plug & Clug approach, and a memory-based strategy. The findings of Afifah's research (2019) indicate that despite being able to tackle the issues they have been given, students continue to demonstrate a novice level of ability.

The findings of this study are identical to those of previous studies. According to research conducted by Tsalatsin and Masturi (2014), pupils have a limited knowledge of interfering material ideas. Research conducted by Mustika (2014) utilizing a test of problem-solving skills indicates that the problem-solving skills of high school students learning about wave materials are still inadequate. Simamora et al. (2016) found in another investigation on the problem-solving ability of light waves that the problem-solving skill of kids at one school was remained poor and not developing.

The researcher proposes that teachers assist pupils in developing their problem-solving skills with regard to light-wave matter, based on the findings of the performed research. This is due to the fact that problem-solving skills are essential for every student in the Physics learning process, particularly in light wave material, which focuses primarily on the analysis of light and dark patterns, interference, diffraction gratings, etc. In addition, teachers must alter the numerous methods of learning that students require in order to acquire new, more complicated knowledge and higher-order thinking skills (Shofiana, Kusaira, & Diantoro, 2019). If students already possess strong metacognitive skills, their problem-solving and conceptual understanding will also improve (Pusptasari, DR, Yuliati, I., and Kuseiri, S., 2014).

STEM-integrated project-based learning is one of the suggested learning strategies (PjBL- STM). PjBL-STEAM is a project-based learning approach that incorporates STEM disciplines (science, technology, engineering, and mathematics). It has the ability to deliver meaningful learning in PjBL-STM since students perform research or studies, solve difficulties, and synthesize information through a particular project (Furi et al., 2018). According to the findings of Tseng et al. (2013), PjBL-STEM can boost students' enthusiasm in learning. The PjBL-STEM learning approach can help pupils develop their cognitive abilities (Addin, 2014). PjBL-STEM has been demonstrated to pique students' interest (Lukman, 2015). PjBL-STEM learning was developed for secondary school science teaching reform (Barlow, Frick, Barker, & Phelps, 2014). Through this education, it is envisaged that students' problem-solving abilities will be sharpened and developed

CONCLUSION

The study discovered that students' problem-solving skills were structured, unstructured, and memory-based. This indicates that students are still novices. The students of class XI science had the highest proportion of problem-solving skills, followed by students of class XI science. Students of class XI IPA-5 are the next in line, followed by students of class IPA. This indicates that the supplied education has not been able to fully develop students' problem-solving skills.

Further research can be conducted to explore the causes of students' low problem solving ability. Researchers suggest the future research for applying various approaches and learning methods that can train students' problem solving skills.

REFERENCES

Addin, I. (2014). Learning Development by Using the STEM Approach with the Help of Student Worksheets to Train Students' Creative Thinking Skills on Static Fluids. *Journal of Physics Education Vol.4 No.3* .

Afifah, P. (2019). Analysis of Concept Mastery and Problem Solving Ability Newton's Law in *Modeling Instruction Learning* with *Web-Based Formative Assessment. thesis* . UM, Malang .

Amalia, R., Sinaga, P., Sari, IM, & Saepuzaman, D. (2016). Identifying the Misconceptions of High School Students in Bandung City on the Concept of Temperature and Heat. *Pros. National Seminar Pend. UM Postgraduate IPA* , *1* .

A zka, M. D. (2017). A Comparative Study of the Problem Solving Ability of Students Who Received the *Pre Solution Posing* Method and the *Post Solution Posing Method* for Class X Mathematics and Natural Sciences Program, Trigonometry Subject at M AN Kendal. *thesis* . UIN Walisongo, Semarang .

Barlow, AT, Frick, TM, Barker, HL, & Phelps, AJ (2014). Modeling Instruction: The Impact of Professional Development on Instructional Practices. *Science Educator*, *23* (1), 14–26.

Buteler, L., & Coleoni, E. (2016). *Solving problems to learn concepts , how does it happen ? A case for buoyancy . 020144* , 1–12. https://doi.org/10.1103/PhysRevPhysEducRes.12.020144

Docktor, JL, Dornfeld, J., Frodermann, E., Heller, K., Hsu, L., Jackson, KA, … Yang, J. (2016). Assessing student written problem solutions: A problem-solving rubric with application to introductory physics. *Physical Review Physics Education Research* , *12* (1), 1–18. https://doi.org/10.1103/PhysRevPhysEducRes.12.010130

Doctor, JL, Strand, NE, Mestre, JP, & Ross, BH (2015). Conceptual problem solving in high school physics. *Physical Review Special Topics - Physics Education Research* , *11* (2), 1–13. https://doi.org/10.1103/PhysRevSTPER.11.020106

Furi, IML, Handayani, S., & Maharani, S. (2018). Experiment Of *Project Based Learning* And *Project Based Learning* Integrated Stem Learning To Increase Students' Learning Outcomes And Creativity In Basic Competency Of Milk Processing Technology . *Journal of Educational Research n (2018) Vol. 35 No. 1.*

Hull, MM, Kuo, E., Gupta, A., & Elby, A. (2013). *Problem-solving rubrics revisited : Attending to the blending of informal conceptual and formal mathematical reasoning . 010105* , 1–16. https://doi.org/10.1103/PhysRevSTPER.9.010105

Istyowati , A. , Kusairi , S. , & Handayanto, SK (2017). *Analysis of Learning and Difficulty of High School Students in Class XI to Mastery of Physics Concept. Proceedings of Semna s III Pend. UM Postgraduate Physics* , *1* .

Jackson, SL (2012). *Research Methods and Statistics: A Critical Thinking Approach* . Cengage Learning.

Ministry of Education and Culture. (nd). *CURRICULUM DOCUMENT 2013* . Retrieved from http://yogyakarta.kemenag.go.id/file/file/dikmad/ldue1388737894.pdf

Lukman, LA (2015). The Influence of the Application of STEM Project Based Learning on the Mathematical Creativity of Vocational High School Students. *Journal of Educational Innovation (JPK) (2015) Vol.4 No.1* : 113–119.

Mestre, P., Ross, BH, & Doctor, JL (2012). *Impact of a short intervention on novices' categorization criteria . 020102* , 1–11. https://doi.org/10.1103/PhysRevSTPER.8.020102

Mustika, M. (201 4). Application of Generative Learning Model in Improving Concept Mastery and Physics Problem Solving Ability in High School Students . *thesis* . UPI , Bandung .

Ni'mah , M.N, Kusairi, S. , & Supriana , E. (2019). Misconception Profile Of Students Of Ma With Different Levels Of Class On Temperature And Heat Learning Materials . *Journal Of Physics Learning* .

Nurul , I. , Endang , P., & tendrils . (2016). Studying the Wave Material Teaching Materials and the Causes of Students' Difficulties in Understanding It . *National Seminar of Physics Department, FMIPA UM* , *1* .

Puspitasari, DR, Yuliati, L., Kusairi, S. (2014). The Relation between Thinking Skill Patterns and Students' Concept Mastery in Thinking Map-Assisted Metacognition Strategy Learning. *Indonesian Journal of Applied Physics (2014) Vol.4 No.2* : 142.

Sofiana , A. _ , Kusairi, S. , & Markus , D. (2019). Critical Thinking Ability and Their Effect on Student Learning Outcomes in Newton's Law . *JOURNAL OF PHYSICS LEARNING* .

Simamora , R. _ M., Sinaga , P. , & Jauhari , A. (2016). Physics Learning Using Multi-representation to Improve Cognitive Ability and Problem Solving Ability of Junior High School Students Subject Vibration and Waves . *Proceedings of SNIPS Pend. UPI Physics* .

Sutopo. (2016). Students' Understanding Of Fundamental Concepts Of Mechanical Wave. *Indonesian Journal of Physics Education,* 12 (1):41—53.

Tsalatsin , N. _ M. , & Masturi . (2014). Determination Of Wave Length Using Simple Double Slope Interference . *Unnes Physics Education Journal* , *4* . Retrieved from http://journal.unnes.ac.id/sju/index.php/upej

Tseng, et al. (2013). The Effectiveness of an Aerobic Exercise Intervention on Worksite Health-related Physical Fitness, A Casein a High-tech Company. *The Cochrane Central Register of Controlled Trials (CENTRAL) (2013) Vol.4 No.1* : 100-6.

Walsh, LN, Howard, RG, & Bowe, B. (2007). Phenomenographic study of students' problem solving approaches in physics. *Physical Review Special Topics - Physics Education Research* , *3* (2), 1–12. https://doi.org/10.1103/PhysRevSTPER.3.020108