Puissant (ISSN print: 2719-0153; ISSN online: 2719-0161)
Vol. 5, pp. 1300-1317
https://puissant.stepacademic.net

Short Paper

Effectiveness of Active Learning Strategy in Improving Students' Conceptual Understanding of Light and Optics

Jhonner D. Ricafort
Sorsogon State University, Philippines
jhonner.ricafort@sorsu.edu.ph

Date received: November 11, 2022
Date received in revised form: December 3, 2022; January 14, 2023
Date accepted: January 22, 2023

Recommended citation:

Ricafort, J. D. (2024). Effectiveness of Active Learning Strategy in Improving Students' Conceptual Understanding of Light and Optics. *Puissant*, 5, 1300-1317.

Abstract

This study aimed to evaluate the effectiveness of the active learning strategy in improving students' conceptual understanding of light and optics. The researcher used mixed methods of research, viz., qualitative and quantitative techniques. It utilized a modified multiple-choice test as the main instrument to obtain the data from the respondents. Analysis of the data shows that from the five subtopics considered, the students got the highest complete conceptual understanding percentage of 81% for the interference of light (WM = 2.73; SD = 055) and the lowest for light reflection (75%). Overall, the students have developed a complete conceptual understanding of light and optics (WM = 2.68; SD = 0.64). All the mean scores have significant differences, as shown by the computed t-values, which are greater than the test values for the entire topics. Thus, the active learning strategy was effective in enhancing the conceptual understanding of the students. The results reinforce the idea that engaging students in active learning can lead to the development of conceptual understanding. The results of the study may provide insights to science teachers about the need to constantly expose their students to lessons and laboratory activities focused on active learning to facilitate the development of conceptual understanding. The Active Learning Strategy can be used in science classes to help students learn more effectively.

Keywords – effectiveness, active learning strategy, conceptual understanding, light and optics

INTRODUCTION

One of the challenges that science education in many developing countries is facing nowadays lies in science instruction. One's teaching effectiveness may greatly increase depending on the teacher's ability to make the most out of the different teaching strategies. Fauth et al. (2019) showed a positive correlation between teacher competence and students' interest. Moreover, the same correlation was observed between self-efficacy and student achievement. The teacher's competence includes pedagogical content knowledge, self-efficacy, and teaching enthusiasm. With the incessant development in science and technology, teachers are confronted with new challenges and are demanded to take on new roles. They are shifting from information gatekeepers to facilitators. These new modifications require students to actively engage in the learning process as opposed to passively observing or listening (Upstate, 2021). To effectively perform these roles, science teachers today should have a deep understanding of the subject they teach as well as the nature and methods of science and its impact on students' daily lives. Researchers on teaching have shown that effective instruction is facilitated by the appropriate content and the selection and utilization of strategies, procedures, and materials within the context and objectives of teaching. Thus, science teachers need to develop expertise such as the knowledge, capacity, skill required to support a diverse range of learners, content knowledge, and pedagogical content knowledge for teaching science (Science teachers' learning, 2016). These competencies are considered as significant factors of student learning. Hakim (2015) showed that social, professional, and personal competencies, which are largely pedagogical, have a major impact on improving student learning outcomes.

These empirical data may provide guidance in the improvement of science education in developing countries such as the Philippines. As reported, the country lagged behind 57 other countries in Math and Science achievements in the 2019 global assessment Trends in International Mathematics and Science Study (Ramos-Araneta, 2020). Likewise, Cordon & Polong (2020) revealed in their analysis of the 2018 results of Programme for International Student Assessment (PISA) that Filipino students score an average of 357 points in Science Literacy, which is significantly lower than the OECD average of 489 points. This means that the science literacy rate is below the OECD standard. However, there is a high level of effort and desire to raise the standard of learning which is demonstrated by revisions in the curriculum, and annual conduct of licensure examination to maintain the quality of teachers. Furthermore, it is recommended that scientific literacy skills may be improved by providing library facilities at the level of membership through a grant program and a variety of educational initiatives.

Anchored in this premise, this study was conducted to evaluate the effectiveness of active learning strategy in improving the students' conceptual understanding of light and optics. The researcher believes that when students are given the opportunities to construct their knowledge of Physics concepts through direct observation of the physical world, they may acquire deeper understanding of the concepts. By developing the conceptual knowledge, science teachers are preparing students to become independent, self-sufficient and productive individuals in order to uplift not only the quality of science education but the country's current economic status as well.

Objectives of the Study

This study aimed to evaluate the effectiveness of the active learning strategy in improving the students' conceptual understanding of light and optics. Specifically, it determined the level of conceptual understanding of the students in topics such as reflection, refraction, interference, diffraction, and polarization, as well as the effectiveness of an active learning strategy in enhancing their conceptual understanding.

RELATED LITERATURE

Active Learning Strategy in Science Teaching

Active engagement of students in learning has been the goal of most of the movements in science education. Effective learning is strongly supported when students are actively engaged in the learning process. Compared to the traditional learning method, active learning facilitates students' acquisition of competency. This is shown by the improvement in the performance of the students exposed to active learning lessons (Shin et al., 2015). Active learning is usually associated with activities that students do to construct their cognition and understanding. Students are engaged both intellectually and emotionally in the learning activities (Johnson & Johnson, 2018). Thus, it involves the use of higher-order thinking skills by the students to do the activities. Likewise, Brame (2016) emphasizes the link between active learning and group work, which means that students collaborate to accomplish the tasks. Working together as a group may result in students' higher achievement, increased retention, and greater social support.

The numerous advantages of active learning suggest the importance of modifying classroom activities to incorporate this strategy in teaching science. Fink (1999) describes a model of active learning that involves some kind of experience or some kind of dialogue. There is a "dialogue with self," which happens when a learner thinks reflectively about a topic, and a "dialogue with others," which happens when learners are involved in a discussion about a topic. The experience is classified into two parts, which are "observing" and "doing." Observing occurs whenever a learner watches or listens to someone else doing something related to what they are learning. "Doing" is described as any learning activity where the learner does something. Santoso et al. (2019) concluded that students with strong problem-solving abilities also have a high level of metacognition and strategic use. They demonstrate awareness of their abilities, are capable of planning their actions, and may choose strategies or special skills to solve problems.

Conditions for Effective Learning

Learning is determined by what the learner brings to the classroom as well as the learning situations that are presented to the learners. Learning takes place when learners are mentally and physically active in the learning process (Smart Sparrow, 2018). Teachers should therefore develop or adopt strategies or learning processes that provide meaningful forms of active learning. Active learning activities that involve some sort of experience or some kind of dialogue may motivate students to be more engaged in the learning process. Several pieces of research show that active learning can increase higher-order thinking and promote deeper learning of science content. Olimpo and Esparza (2020) underscore that evidence from the STEM disciplines (science, technology, engineering, and math) shows that participation in the learning process is essential for students to build conceptual understanding in their chosen field of study. The degree to which educators intentionally integrate active-learning strategies (ALSs) into their courses determines how successful they are in fostering this kind of engagement. To help students gain a thorough knowledge of the material, ALSs should be specifically matched to clear student learning objectives and methods of evaluation.

Likewise, Freeman et al. (2014), compared the use of active learning to the traditional lecture in improving the academic performance of students in undergraduate science, technology, engineering, and mathematics (STEM). The effect sizes indicate that on average, student performance on examinations and concept inventories increased under active learning (n = 158 studies) and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). It further indicates that average examination scores improved by about 6% in active learning sections and that students in classes with traditional lecturing were 1.5 times more likely to fail than students in classes with active learning. Furthermore, Sulisworo and Sutadi (2017) investigated the impact of using the science learning cycle (SLC) model on improving scientific literacy in secondary vocational schools. The result showed that the conceptual understanding of the students in the treatment group who applied methods such as SLC was better than that of the control group. Similarly, Abdi (2014) investigated the effects of the inquiry-based learning method on students' academic achievement in science lessons. The results showed that students who were instructed through inquiry-based learning using the 5E learning cycle achieved a higher score than those who were instructed through the traditional method.

Constructivism Learning Theory

Studies conducted on active learning are supported by constructivist theory, which posits that students learn by constructing ideas from experience. It is regarded as a very effective model for outlining how students learn as well as how information is generated in the real world, showing notable effectiveness in fostering student learning (Shah, 2019). Teaching cannot be viewed as the passive transmission of knowledge from teacher to student. The theory advocates student-centered learning under the guidance of teachers. Thus, they serve as organizers, mentors, aides, and facilitators of learning (Xu & Shi, 2018).

Because it broadens learning experiences, a learning model that allows for experience and dialogue incorporates more active learning into science teaching. Allowing the students to form small cooperative groups maximizes their interaction. Likewise, when students are engaged in cooperative activities, they seek outcomes that are beneficial to themselves and all other members of the group. This maximizes their own and each other's learning. Thus, it contributes to the total picture of making learning a deeper, more engaging, meaningful, active, and effective process. Asking for students' predictions before doing observations makes the learning experience richer and more engaging. Proving predictions by doing experiments provides an opportunity for learners to sense what they are doing and what they need to learn by doing. In the process, they develop a deeper conceptual understanding.

RESEARCH METHODOLOGY

Research Design

To determine the effectiveness of the active learning strategy in improving the conceptual understanding of the students in Light and Optics, the researcher made use of mixed-methods research—quantitative and qualitative techniques—in the study. This was chosen as it provides a more complete understanding of research problems than either approach alone. One of its advantages is that it helps to cross-validate relationships between variables, as when quantitative and qualitative methods are compared to see if they converge on a single interpretation of a phenomenon (Fraenkel et al., 2012). The qualitative part involves the analysis of the conceptual understanding from the written explanations of the students for every test item. On the other hand, the quantitative technique was used to compare the results of the pretest and posttest of the students. This was done to further validate the qualitative data obtained from the respondents.

The Respondents

The study involved second-year college electrical technology students of Sorsogon State University as respondents. They were purposively chosen since their applied science curriculum specifically includes lessons on light and optics. This was conducted using one class, which consisted of 40 students. The class was divided into six small cooperative groups, each composed of six to seven members. These students were grouped heterogeneously.

Research Instrument

The level of conceptual understanding of the students was measured using a modified multiple-choice test, which was validated by the physics teachers and professors who are experts in their field. A dry run was conducted to determine its reliability. Results of the internal consistency test using Kuder Richardson Formula 20 showed a test statistic value of 0.822, which indicates the high reliability of the instrument. The modification of the multiple-choice test requires the students to explain their answers to every question. Hence, a thorough qualitative analysis was done to determine the conceptual understanding of the students who were taught using the active learning strategy. The explanations provided by the students in the test were categorized into four groups using a scoring rubric: complete understanding, partial understanding, faulty understanding, and no understanding.

Data Gathering Procedure

The data were gathered from the students' answers to the pretest and posttest. Before the data gathering, the researcher sought permission from the dean to conduct the study. The light and optics lessons were taught using an active learning approach based on Fink's experience and dialogue model (1999). Before the lessons were discussed, a pretest was given to the students. Afterward, the lessons were conducted using the following sequence: "dialogue with self", "experience of doing", "experience of observing", and then "dialogue with others". The dialogue with self-phase allows students to think about a topic in a reflective manner, either by asking themselves what they think or should think. This section began by asking students to predict what would happen to something under certain conditions. The students would have the experience of doing phase-by-phase experiments to prove their given predictions. An activity sheet that describes the procedure of the experiment was given to them as their guide. The experience of observing phase happened as the students were doing their experiment. Grouping the students into cooperative groups allowed them to interact with one another, and this is where the phase of dialogue with others comes in. However, after performing the experiments, some groups are called to discuss the results of their experiments with the class. The purpose of this is to make the dialogue with others phase more dynamic and active, as this may lead to a class discussion of the lesson. After the implementation of the lessons, a posttest was given to the students.

Statistical Tools

Appropriate statistical measures were employed to quantify the data that were collated to answer the problems set out in the study. Frequency count and percentage were used to determine the level of conceptual understanding of the students. Likewise, a weighted mean and standard deviation were used to describe their level of conceptual understanding. A t-test for dependent samples was also utilized to determine the significant difference between the pretest and posttest results.

RESULTS

Level of Conceptual Understanding of Students in Light and Optics

The level of conceptual understanding of the students in light and optics was determined through a modified multiple-choice type of test. Each test item was given a score of three for the correct answer and the correct explanation, two for the correct answer and a partially correct explanation, one for the correct answer, and zero for the wrong answer.

Table 1. Level of Conceptual Understanding of the Students in Light and Optics

Topics	Level of Conceptual Understanding								WM	SD
	CU		PU		FU		NU			
	f	%	f	%	f	%	f	%		
Reflection	180	75%	40	17%	13	5%	7	3%	2.63	0.73
Refraction	183	76%	29	12%	18	8%	10	4%	2.60	0.74
Interference	195	81%	31	13%	8	3%	6	3%	2.73	0.55
Diffraction	158	79%	29	15%	8	5%	4	2%	2.70	0.63
Polarization	218	78%	49	18%	8	2%	5	2%	2.72	0.58
Overall	**185**	**77%**	**35**	**15%**	**12**	**5%**	**8**	**3%**	**2.68**	**0.64**

Legend: *CU – Complete Understanding* *PU – Partial Understanding* *f – frequency*
FU – Faulty Understanding *NU – No Understanding*
WM – Weighted Mean *SD – Standard Deviation*

Table 1 shows the level of conceptual understanding of the students in light and optics. As reflected, the students had the highest complete conceptual understanding percentage for the interference of light (WM = 2.73; SD = 055). This is followed by the diffraction of light (WM=2.70; SD = 0.63) and the polarization of light (WM = 2.72; SD = 0.58). On the other hand, the reflection of light obtained the lowest percentage of complete understanding (WM = 2.63; SD = 0.73). In terms of partial understanding of the concept, it further shows that the polarization of light had the highest percentage among the identified topics and was closely succeeded by reflection and diffraction. Generally, most of the students developed a complete understanding of the concepts on topics in light and optics (WM = 2.68; SD = 0.64).

Effectiveness of Active Learning Strategy in Enhancing Conceptual Understanding of the Students

The pretest and posttest for each topic designed for active learning were composed of modified multiple-choice test items. The items that were used to measure conceptual understanding were those classified as remembering, understanding, applying, and analyzing based on Anderson and Krathwohl's revised Bloom's taxonomy of objectives. The results of the pretest and posttest of the students were compared using a t-test for correlated samples.

Table 2 shows the t-test results for the conceptual understanding of the reflection of light. By comparing the computed t-value and tabular value at a 0.05 level of significance, it is shown that all the mean scores have significant differences. It can be noted that the highest test value was obtained for item 3 which specifically evaluates the students' understanding of the laws of reflection. On the other hand, item 5 got the lowest test value of 8.25. This item deals with the assessment of student's knowledge of the behavior of light when it strikes a plane mirror.

Table 2. T-test Results for Conceptual Understanding in Reflection of Light

Item No.	Pretest	Posttest	Computed t-Values	Tabular Value
1	1.30	2.68	9.98	
2	0.43	2.50	11.73	
3	0.18	2.60	16.01	2.02
4	0.43	2.80	13.63	
5	1.15	2.50	8.25	
6	0.35	2.65	13.63	

*$p > 0.05$ (significant) $df = 39$

Similarly, table 3 shows the t-test results for the conceptual understanding of the refraction of light. It can be gleaned that the computed t-value and tabular value showed that all the mean scores have significant differences. Item number 10 got the highest test value followed by item number 9. The former assesses the knowledge of the students on the behavior of light as it passes through different media such as air, water, and glass. Moreover, the latter evaluates students' understanding of the effect of the refraction of light highlighting mirage as a natural phenomenon. Meanwhile, the lowest test value is obtained for item 12 which evaluates students' knowledge of the conditions for the occurrence of light refraction.

Table 3. T-test Results for Conceptual Understanding in Refraction of Light

Item No.	Pretest	Posttest	Computed t-Values	Tabular Value
7	0.15	2.43	14.58	
8	0.83	2.60	12.16	
9	0.33	2.63	17.68	2.02
10	0.30	2.70	17.93	
11	0.80	2.88	13.90	
12	0.25	2.23	10.16	

*$p > 0.05$ (significant) $df = 39$

Likewise, table 4 shows the t-test results for the conceptual understanding of the interference of light. It can be gleaned that the computed t-value and tabular t-value show significant differences in all the mean scores. As reflected, item number 14 got the highest test value followed by item number 15. Both these items require the students to identify the types of interference based on the patterns of fringes on the screen formed when the laser light passes through a narrow slit. On the other hand, it can be observed that the lowest test value is obtained for item number 17 which assesses students' understanding of the constructive interference of light.

Table 4. T-test Results for Conceptual Understanding in Interference of Light

Item No.	Pretest	Posttest	Computed t-Values	Tabular Value
13	0.18	2.38	14.02	
14	0.48	2.98	31.22	
15	0.58	2.95	30.64	2.02
16	0.35	2.83	21.87	
17	0.40	2.50	13.18	
18	0.55	2.58	13.93	

**p* > 0.05 (significant) *df* = 39*

Moreover, table 5 reflects the t-test results for the conceptual understanding of the diffraction of light. It can be noted that the computed t-value and tabular value shown have significant differences in all the mean scores. It can also be seen that item number 20 comes in second with item number 21 having the highest test value. The former evaluates the student's knowledge of the factors that affect the amount of diffraction while the latter deals with the explanation for the occurrence of the said phenomenon. In contrast, item number 23 got the lowest test value. This item requires the students to distinguish particle property from wave property of light in a given example.

Table 5. T-test Results for Conceptual Understanding in Diffraction of Light

Item No.	Pretest	Posttest	Computed t-Values	Tabular Value
19	0.33	2.70	15.34	
20	0.38	2.75	20.29	
21	0.43	2.78	25.64	2.02
22	0.18	2.55	15.34	
23	0.48	2.60	14.32	

**p* > 0.05 (significant) *df* = 39*

Furthermore, table 6 shows that all the average computed t-values are greater than the tabular value of 2.02 at a 5% level of significance with 39 degrees of freedom for the polarization of light. It is worth noting that item number 24 obtained the highest test value. This item allows the students to describe the intensity of light when it gets polarized by the material. Likewise, item number 29 got the second-highest test value.

Table 6. T-test Results for Conceptual Understanding in Polarization of Light

Item No.	Pretest	Posttest	Computed t-Values	Tabular Value
24	0.15	2.80	26.94	
25	0.18	2.55	21.31	
26	0.38	2.55	14.36	
27	0.38	2.73	17.21	2.02
28	0.43	2.88	22.87	
29	0.43	2.80	23.92	
30	0.23	2.70	18.87	

$*p > 0.05$ (significant) $df = 39$

The said item focuses on identifying the change in the intensity of light when two polaroid sheets are rotated through one complete rotation at the same rate in opposite directions. On the contrary, item number 26 which assesses students' understanding of the relationship between the axis of polarization and the intensity of light got the lowest computed t value.

DISCUSSION

The preceding results show that interference of light has the highest percentage of complete understanding. This means that the students were able to clarify their understanding of the concept explored in the topic. Figure 1 presents this level of understanding.

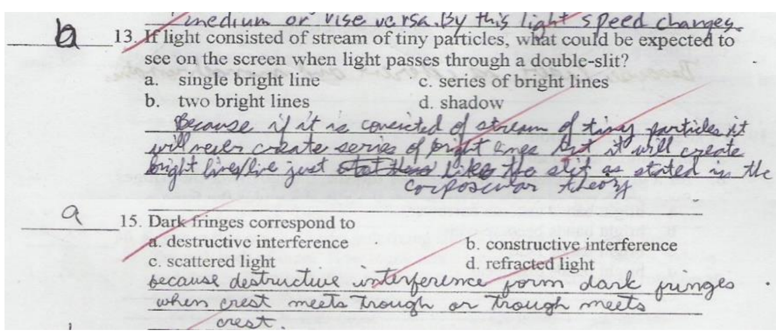

Figure 1. Sample responses of the students reflecting a complete understanding of the concept

As revealed in their responses in the posttest, students were able to provide correct explanations of their answers to the items on this topic. The explanation of the student in the first item indicates a thorough understanding of the interference of light, which is a wave phenomenon. The response in the second item likewise shows consistency with the scientific descriptions of destructive interference. This also suggests that they had acquired knowledge and understanding of light interference.

On the other hand, the reflection of light obtained the lowest percentage of complete understanding indicating that some students were not able to clarify their knowledge of the concept. These students may have developed a partial understanding of light reflection. Furthermore, the polarization of light having the highest partial understanding implies that some students were not able to give adequate explanations despite the correct selection of choices. This shows that students' understanding may not be sufficient to explain the phenomenon. Figure 2 shows this level of understanding.

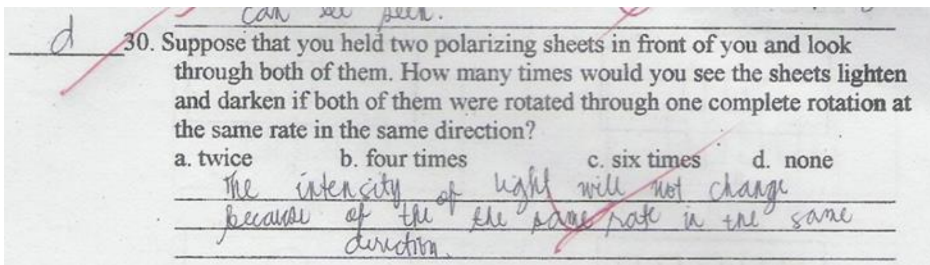

Figure 2. Sample responses of the student reflecting a partial understanding of the concept

The sample explanation in the item shows that the student was not able to clearly express the answer. The student failed to mention the axis of polarization of the material, which is responsible for the change in intensity of light, although the orientation was correctly described in the answer. This means that students might not master the concepts well. Meanwhile, the fact that refraction of light has the lowest percentage of partial understanding does not imply that students have a better understanding of the concept than the polarization of light. As evidently shown, both topics varied in the percentage of students who had a faulty or no understanding of the concepts. In fact, in the refraction of light, the students had the highest degree of faulty understanding. This suggests that students correctly answered the items but could not give a correct explanation of the concept. The explanations may lack clarity and consistency with the question. It was observed that a few students did not fully comprehend or learn the concept, and they may have simply guessed the correct answer for the items. Figure 3 reflects this level of understanding.

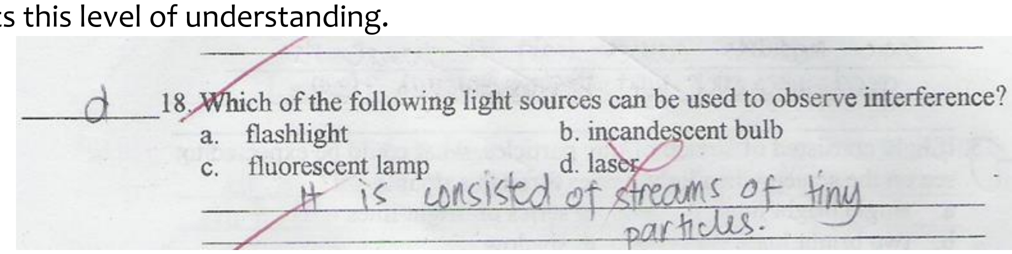

Figure 3. Sample responses of the students reflecting a faulty understanding of the concept

The explanation of the student in the item was confusing and did not jibe with the scientific descriptions of laser light. This implies that a few students may not have given more focus during the dialogue with others or the post-laboratory discussion. The misconception was retained in their minds despite the clarifications and questions made by the groups during the discussion. This indicates that although the students take great responsibility for their education through active learning, this may not mean that it displaces the role of a teacher as a facilitator of learning. Thus, they must possess strong pedagogical content knowledge as well as the learning principles to ensure the active engagement of the students in the lesson.

Furthermore, the data presented earlier reflects the percentage of students who had no understanding of the concepts of light and optics. As revealed, the refraction of light had the highest no-understanding percentage. This means that the students gave wrong answers and failed to provide explanations or correct descriptions of the concept as required in the test items. Figure 4 manifests this level of understanding.

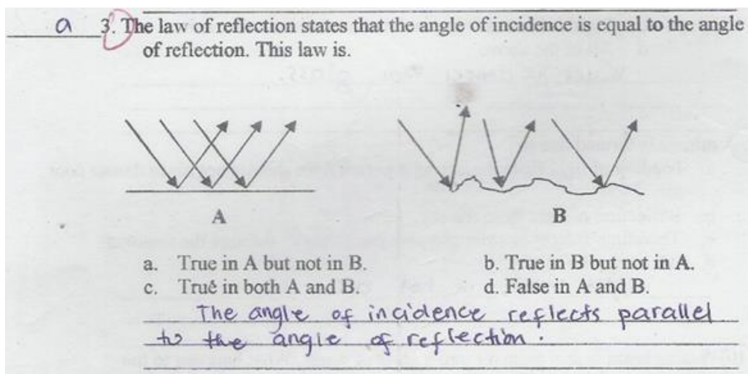

Figure 4. Sample response of the students' reflecting a no understanding of the concept

The sample answer of the student in the item was wrong. This implies that the concept of reflection was not learned by the student. Such failure may be attributed to absences from the class or a lack of interest in participating in the activity. Thus, it may be important for teachers to encourage the students to regularly attend classes so that they do not miss the lesson and ensure active participation in the activity. In general, most of the students developed a complete understanding of the concepts on topics in light and optics. On the other hand, only a few gained a faulty or no understanding of the concepts of reflection, refraction, interference, diffraction, and polarization light. This means that the instruction on active learning has a positive impact on their learning.

The above results discussed are supported by the study of Sulisworo et al. (2017) about the Science Learning Cycle (SLC) Method to enhance the conceptual understanding and learning independence of physics learning. The findings showed that the conceptual understanding of the students in the treatment group who applied methods such as SLC was better than that of the control group. Similarly, Cleveland et al. (2017) found that there is a relationship between instructors' use of active-learning strategies and students' conceptual understanding and affective changes in introductory biology. The students in both active-learning environments displayed similar and significant learning gains.

Meanwhile, the significant differences in the mean scores of students on the test for the reflection of light imply that the active learning strategy was effective in developing the students' conceptual understanding. These enhancements in conceptual understanding were manifested by the changes that the students made to their answers from the pretest to the posttest. The laboratory activity designed with an active learning strategy benefited them through dialogue with others, which allowed them to realize their mistakes during the laboratory proper. The dialogue with others phase is the post-laboratory discussion, which is the active learning equivalent of the traditional method of laboratory activity. As observed during the conduct of the laboratory activity, the students were able to realize their misconceptions as they actively engaged in the discussion with others. The result means that even though active learning provides the students with an opportunity to learn the concepts by themselves, the teacher still plays an important role as the facilitator of learning, specifically in instances where students could not thoroughly understand the results of experiments. Thus, the teacher as a facilitator must be well-prepared and knowledgeable of the content of the lesson on active learning. The laboratory instructions improved the prior knowledge of the students because they were allowed to do self-reflection and self-discovery of the concepts. This also means that in the active learning strategy, the laboratory activity was effective because the students confirmed the facts behind their previous knowledge.

As regards the significant variances in the mean scores for conceptual understanding of the refraction of light, the result implies that the active learning strategy may have been effective in enhancing most of the concepts studied. The enhancement of the student’s concept of refraction could probably be attributed to the laboratory activity performed that allowed them to verify their predictions about the phenomenon. Reflective thinking is essential in developing conceptual understanding and process skills for lifelong learning in science activities. This result is consistent with the findings of Nuñez, et al. (2021) which showed that the use of active learning strategies accompanied by methodological tools such as collaborative work has an impact on the level of disciplinary knowledge of students. Specifically, the study's participants improved their level of conceptual understanding in physics after using active learning strategies, as indicated by the results, which showed a substantial rise with a value of 0.49 at the conclusion of the intervention. The students may have benefited from the "dialogue with others," which is a form of cooperative learning. The group discussion and presentation of the activity results provide them with an opportunity to compare answers and clarify misconceptions about the topic. Tran (2019) revealed that cooperative learning has a significant impact on student motivation in an experimental group as compared to the control group exposed to the traditional method of teaching. Hence, it was suggested to promote this method for better learning outcomes. As an implication, teachers must be knowledgeable of alternative techniques and strategies for questioning and discussion and must create a supportive intellectual and emotional environment that encourages students to take risks.

In terms of interference of light, the significant differences in all the mean scores indicate that the active learning strategy may have a positive effect on the improvement of students' conceptual understanding. This is clearly shown in their answers to the pretest and posttest. The students enhanced their conceptual understanding of the interference of light. The activity performed by the students made them develop a deeper understanding of the concept. Allowing them to make predictions before the activity during the dialogue with themselves phase is effective in learning the basic concepts. Research shows that active learning is much better recalled, enjoyed, and understood because it requires the students to make their own meaning, which develops their conceptualizations of what they are learning. During the process, they physically make neural connections in their brain, which is called learning. The active learning strategy specifically enhanced the students' conceptual understanding of the qualitative relationship between the slit spacing and the separation of the fringes. The activity of the students about the interference allowed them to observe the patterns of light formed on the screen. Their observations were compared to their predictions made during the dialogue with themselves. They likewise compared and analyzed the patterns of light formed by different slits. As a result, the students may have learned and retained the concepts for a longer period of time. Likewise, the students had improved their understanding of the type of light source that can be used to easily observe the interference of light. This means that the activity performed made them completely understand the concept of light interference. The students benefited from the dialogue with others, where they compared and discussed the results of the activity. It was observed during class interaction that the groups had clarified why lasers were used in the experiment.

Along with the diffraction of light, the significant differences in all the mean scores suggest that the active learning strategy is useful in improving the concept of diffraction. This is also shown in their answers to the pretest and posttest. The students improved their conceptual understanding of the relationship between the width of the slit and the fringe spacing. In the laboratory activity performed by the students, they were asked to compare the patterns of light formed on a distant screen when laser light passed through slits of different widths. Based on their observations, all groups stated in the worksheet that as the slit is made narrower, the central bright fringe and the side fringes spread out and become larger. This concept was retained longer in the minds of the students because of their hands-on experience during the lesson. Science concepts are indeed better learned and understood by doing laboratory activities as part of active learning. The students improved their conceptual understanding of the factors that affect the amount of light diffraction. This means that the laboratory activity of the students made them completely understand the concept of light diffraction. In the activity, the students learned that the size of the slit affects the diffraction of light. However, since they only used a single frequency of light in the activity, during the dialogue with others they discussed among themselves how wavelength affects the diffraction of light in a particular slit. The students' discussion during the dialogue with themselves clarified their misconceptions about the topic, resulting in effective learning of the concept. As an implication, students should be exposed to lessons designed for active learning to develop a deeper understanding of concepts.

In relation to the polarization of light, significant differences in all the mean scores denote that an active learning strategy helps improve understanding of the concept. Active learning was indeed effective in developing the students' complete understanding. The experience of doing phase, which is equivalent to laboratory proper in the traditional method of teaching, benefited students. However, the students acquired a deeper understanding and longer retention of concepts in polarization lessons because they used an active learning strategy. The answers of the students in the test showed that they likewise enhanced their conceptual understanding of the axis of polarization of the material. Because of the hands-on and minds-on activities, the students' complete understanding may have developed. It can be mentioned that in the activity, the students used polarizing sheets, which allowed them to observe how the intensity of light varied with the orientation of the axes of polarization. The learning of concepts was strengthened when the students were actively involved in the process of learning and, more importantly, when they experienced the science concepts in the activity designed for active learning. Generally, the results show that the conceptual understanding of the students on selected topics in light and optics was significantly improved. This also means that an active learning strategy is effective in developing a complete understanding of physical concepts. The result is parallel to the findings of the study by Abdi (2014) on the effect of inquiry-based learning methods on students' academic achievement in a science course. It was concluded that there is a significant difference between the achievement levels of the students who have been educated by inquiry-based instruction supported by the 5E learning cycle and the students who have been educated by traditional teaching methods. The students who have been educated by inquiry-based instruction supported by the 5E learning cycle method have become more successful than the students who have been educated by traditional teaching methods.

CONCLUSIONS

The use of an active learning strategy that allows the students to engage in laboratory activities and involve different phases of learning such as dialogue with themselves, the experience of doing and observing, and dialogue with others can lead to the development of a complete conceptual understanding of the topics in light and optics. Specifically, the active learning strategy is effective in improving the conceptual understanding of the students on topics such as reflection, refraction, interference, diffraction, and polarization. This reinforces the idea from previous research that engaging students in active learning can lead to the development of a deeper understanding of concepts.

RECOMMENDATIONS

Based on the conclusions drawn, it is recommended that active learning may be integrated into teaching physical concepts to improve students' learning. Moreover, faculty may constantly engage the students in lessons and laboratory activities designed for active learning to ensure the development of a complete understanding of the concept. Other lessons and activities in physics may be developed using a similar strategy to further improve the students' conceptual understanding. In addition, an enhancement seminar and workshop on active learning for science teachers may be conducted. Finally, future research along the active learning strategy in teaching physics may be conducted using other variables and methods to strengthen this study.

IMPLICATIONS

The findings of this study are significant because they show teachers that using an active learning strategy in science instruction improves students' performance in terms of developing a complete understanding of physical concepts. It may also encourage science educators to continue to innovate in order to ensure that students learn effectively. The school administrators may realize the need to strengthen support for instruction by providing adequate science equipment and facilities and building capacity for the faculty to acquire strong teaching competencies. The results of this study may also provide directions for improving the quality of education at the institution. The study's facts and information may assist curriculum planners in designing and enriching curricula that can accomplish and translate learning experiences. In addition, it hopes to develop awareness among experts on the importance of learning physics.

ACKNOWLEDGMENT

The researcher extends his sincere gratitude to the Sorsogon State University Research, Extension, and Training for the assistance provided in the completion of this study. Likewise, to the Dean of the College of Technology and the second-year electrical technology students who served as respondents to this study.

DECLARATIONS

Conflict of Interest

The author declares no conflicts of interest in the conduct of the study.

Informed Consent

The author declares that the respondents have been properly informed before the conduct of the study.

Ethics Approval

Approval to conduct the study was obtained.

REFERENCES

Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in a science course. *Universal journal of educational Research, 2*(1), 37-41.

Smart Sparrow. (2018). Active Learning. Retrieved from https://www.smartsparrow.com/what-is-active-learning/Brame, C. (2016). *Active learning*. Vanderbilt University Center for Teaching.

Cleveland, L. M., Olimpo, J. T., & DeChenne-Peters, S. E. (2017). Investigating the relationship between instructors' use of active-learning strategies and students' conceptual understanding and affective changes in introductory biology: A comparison of two active-learning environments. *CBE—Life Sciences Education, 16*(2), ar19.

Cordon, J. M., & Polong, J. D. B. (2020). Behind the Science literacy of Filipino students at PISA 2018: A Case study in the Philippines' Educational System. Integrated Science Education Journal, 1(2), 70-76.

Council, T. A., & National Academies of Sciences, Engineering, and Medicine. (2016). Science teachers' learning: Enhancing opportunities, creating supportive contexts. National Academies Press.

Fauth, B., Decristan, J., Decker, A. T., Büttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The effects of teacher competence on student outcomes in elementary science education: The mediating role of teaching quality. *Teaching and Teacher Education, 86*, 102882.

Fink, L. D. (1999). *Active learning. Instructional Development Program*. The University of Oklahoma.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410-8415.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). How to design and evaluate research in education (Vol. 7, p. 429). New York: McGraw-hill.

Hakim, A. (2015). Contribution of competence teacher (pedagogical, personality, professional competence and social) on the performance of learning. The International Journal of Engineering and Science, 4(2), 1-12.

Johnson, D. W., & Johnson, R. T. (2018). *Cooperative learning: The foundation for active learning. Active learning—Beyond the future*. Retrieved from https://www.intechopen.com/chapters/63639

Nuñez, R. P., Hernández, C. A., & Gamboa, A. A. (2021). Active learning and knowledge in physics: a reading from classroom work. In *Journal of Physics: Conference Series* (Vol. 1981, No. 1, p. 012007). IOP Publishing.

Olimpo, J. T., & Esparza, D. (2020). Active learning and conceptual understanding in biology. In J.J. Mintzes, and E. M. Walter (Eds.), *Active learning in college science* (pp. 43-57). Springer, Cham.

Ramos-Araneta, M. (2020). *PH lags behind 57 countries in Math, Science – TIMSS*. Retrieved December 20, 2022, from https://manilastandard.net/news/national/343040/ph-lags-behind-57-countries-in-math-science-timss.html

Santoso, F. E., Napitupulu, E. E., & Amry, Z. (2019). Metacognitive level analysis of high school students in mathematical problem-solving skill. *American Journal of Educational Research, 7*(12), 919-924.

Shah, R. K. (2019). Effective constructivist teaching learning in the classroom. Shah, RK (2019). Effective Constructivist Teaching Learning in the Classroom. Shanlax *International Journal of Education, 7*(4), 1-13.

Shin, H., Sok, S., Hyun, K. S., & Kim, M. J. (2015). Competency and an active learning program in undergraduate nursing education. *Journal of Advanced Nursing, 71*(3), 591-598.

Sulisworo, D., & Sutadi, N. (2017). Science Learning Cycle Method to Enhance the Conceptual Understanding and the Learning Independence on Physics Learning. *International Journal of Evaluation and Research in Education,* 6(1), 64-70.

Tran, V. D. (2019). Does Cooperative Learning Increase Students' Motivation in Learning? *International Journal of Higher Education, 8*(5), 12-20.

Upstate, H. (2021). *Technology is changing the roles of teachers and students*. Retrieved from https://hackupstate.medium.com/technology-is-changing-the-roles-of-teachers-and-students-c34c54f24531

Xu, Z., & Shi, Y. (2018). Application of constructivist theory in flipped classroom-take college English teaching as a case study. *Theory and Practice in Language Studies, 8*(7), 880-887.

Author's Biography

Dr. Jhonner D. Ricafort is an associate professor at Sorsogon State University (SorSU), Sorsogon City, Philippines. He has been teaching Applied Science subject at the College of Technology and is currently a part-time faculty of the Graduate School handling major and foundation subjects for Master of Arts in Education major in Science Education.