USING ACTIVITY SHEET TO ENHANCE STUDENT RECOGNITION ABOUT THE CONCEPT OF THE OPTICAL PATH DIFFERENCE IN DOUBLE-SLIT INTERFERENCE

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ABSTRACT

This research aimed to enhance student recognition about the concept of the optical path difference in double-slit interference. A teaching tool called 'activity sheet' was used to help students visualize light waves and realize the key concept of light interference; that is the optical path difference (OPD). The sinusoidal waves with light rays printed on the transparencies was used to represent light waves in this tool. The activity sheet was applied to the Physics 3 class at Demonstration School of Suan Sunandha Rajabhat University in the academic year 2022. It was adding during the instruction about the OPD in double-slit interference. The pre-test and post-test were used to assess students' understanding in this study. The post-test results indicated that more than half of the students gave the correct answer. However, the class average normalized gain in overall was at the low level. It was also found that many students could be used concept of OPD in solving the problem about interference after they had learnt with the activity sheet.

Keywords: activity sheet / double-slit / interference / light / optical path difference

INTRODUCTION

Interference of light is one of the most important topics in wave optics. The principle of interference can be used to describe the bright and dark fringes on the screen when the light waves passing through a double-slit. However, teaching students to understand the concept of interference is quite difficult because we cannot visualize the light waves directly with naked eyes. Many previous studies (Wosilait et al., 1999; Ambrose et al., 1999; Kocakulah & Kural, 2010; Kryjevskaia et al., 2013) revealed that the students still have misunderstandings after they had learned in the topic of double-slit interference. The results also indicated that many students did not recognize that the key concept of double-slit interference was the path difference (Wosilait et al., 1999).

LITERATURE REVIEWS

In physics education research, there are many alternative teaching approaches that can help improve the effectiveness of teaching such as Interactive lecture demonstration (Sokoloff & Thornton, 1997), Peer instruction (Mazur, 1997), Tutorials (McDermott et al., 1998), and Just-in-time teaching (Novak et al., 1999). These teaching methods help increase the student participation and the student/teacher interaction in the classroom. In addition, the study on physics education indicated that increasing student engagement in classroom by using a demonstration kit could help improve students' learning (Crouch et al., 2004).

Over the years, many effective research-based demonstration tools have been created in several fields of physics, including optics (Baierlein & Miglus, 1991; Sawicki, 2001; Planinsic & Slisko, 2005; Kaewkhong & Chitaree, 2015). These tools are designed to help students understand the physics concept and visualize physics phenomena more easily. It motivated the researcher to create an instructional tool that help students understand double-slit interference. It is expected that this teaching tool could be used to enhance student recognition about the concept of the path difference in double-slit interference and visualize light wave more easily.

METHODS

Sample Group

Data were obtained from grade 11 math-science students enrolled in the Physics 3 course at demonstration school of Suan Sunandha Rajabhat University in the second semester of academic years 2022 (N = 18). In the course, there were two lectures per week, each lecture lasted for one and a half hour.

Teaching Plan

The teaching procedure of double-slit interference begins with stimulating students' interest by using a real experiment. First, the lecturers introduced an experimental equipment which consist of a high intensity laser pointer and a double-slit. The demonstration was performed by shooting a laser through the slits and then what happened on the screen was discussed.

Table 1

Double-slit interference teaching procedure.

Step	Task	Time (minutes)
1	Survey students' idea by using pre-test	10
2	Demonstrate double-slit experiment	10
3	Teach with the activity sheet • Optical path difference	55
4	Teach with the workbooks	45
	• Derivation of the formula $d\sin\theta = m\lambda$ • Example of using $d\sin\theta = m\lambda$ in solving problem	
5	Evaluate students' understanding by using post-test	10
	Total	**130**

In this year, an 'Activity Sheet' has been added during the instruction about the optical path difference in double-slit interference. The activity sheet is different from the general worksheet that it adds a simple demonstration kit into the worksheet. In addition to taking notes on the worksheet and seeing demonstrations performed by the lecturers in front of the classroom, the students had to practice with the activity sheet by themselves. During learning, the students were asked to operate the activity sheet in pairs according to Planinsic and Slisko (2005). This would help the students think by themselves and discuss with their friends.

In addition to the activity sheet, the worksheet was also given to each student. It was used to teach the the formula $d\sin\theta = m\lambda$. The teaching covered about 2 lectures. The teaching procedure for teaching double-slit interference are concluded in Table 1.

The Test and Analysis Method

The pre-test and post-test adapted from Ambrose et al. (1999) as shown in appendix were used to assess students' understanding about the optical path difference and the formula $d\sin\theta = m\lambda$ in double-slit interference. The students were asked to complete the pre-test before lecturing about double-slit interference. The post-test was collected one week after the instruction. Student' responses to the tests were analyzed to investigate students' understanding.

The Activity Sheet

Figure below shows the double-slit diagram with the transparent strips on the activity sheet. The teaching procedure with the activity sheet is divided into 4 steps as shown in the following.

Step 1: Using the transparent strips to solve whether at each determined point (a-f) the interference is constructive or destructive.

Step 2: Drawing a line to create a screen and finding the points where the constructive interference occurred on the screen.

Step 3: Determining the difference of the path length of the two wave paths (in term of wavelength) at the first and second constructive interference on the screen.

Step 4: Finding the type of interference at point 'g' without using the transparent strips.

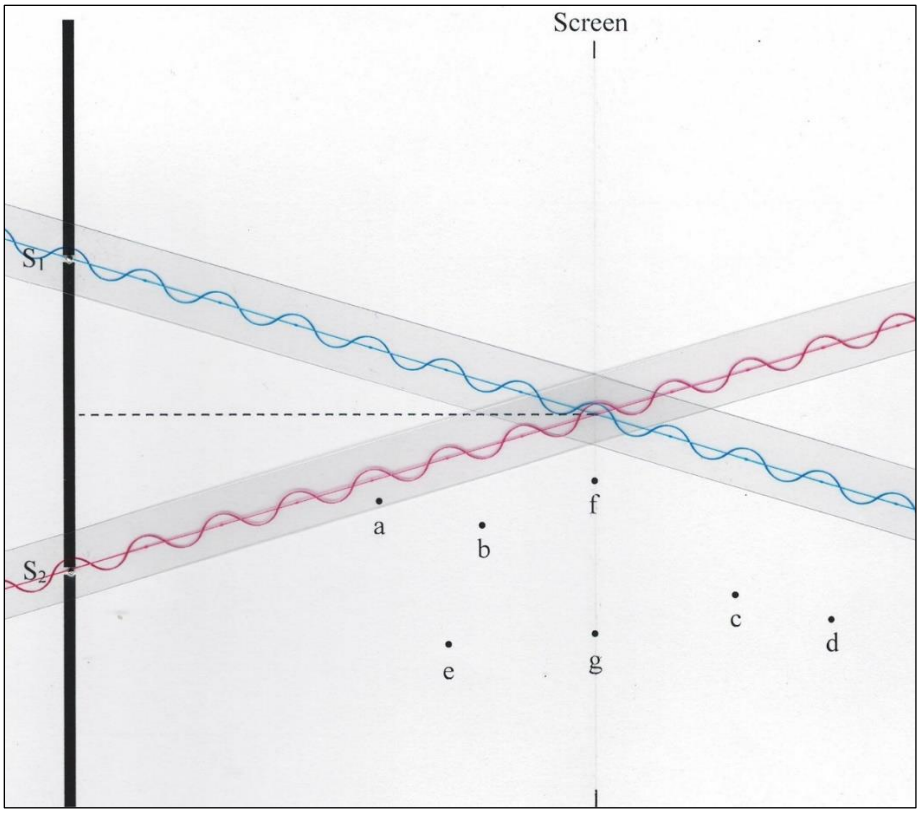

Figure 1 The double-slit diagram with the transparent strips in the activity sheet.

RESULTS

Number of Students with Correct Answers

First, the number of students with correct answer was examined. The results are shown in Table 2. Table 2 indicates that the students gave more correct answer after they had learned the lesson. The Wilcoxon signed-rank test (Gibbons & Chakraborti, 2011) was then used to compare the percentages of students with correct answer between pre-test and post-test. The result indicated that there was a significant difference between pre-test and post-test ($p < 0.01$).

Table 2

Percentages of students with correct answer on the type of interference.

Percentages of students with correct answers	
Pre-test (%)	**Post-test (%)**
20.8	63.6

Class Average Normalized Gain

From the results, the number of students with correct answer were converted to the student scores. The class average normalized gains or <g> (Hake, 1988) were then calculated. In overall, the use of activity sheet gave the class average normalized gains at the low level (<g> = 0.25).

Student Approaches to Solving Problem

Students' approaches to solving problem were categorized; especially those who use the optical path difference (OPD). In addition to analyze which approaches that the students mostly used in solving problem, we also look deep into the details of the percentage of students with correct answer (constructive/destructive interference with correct reasoning). Figure 2 shows student who used the optical path difference to solving problem with correct and wrong answer.

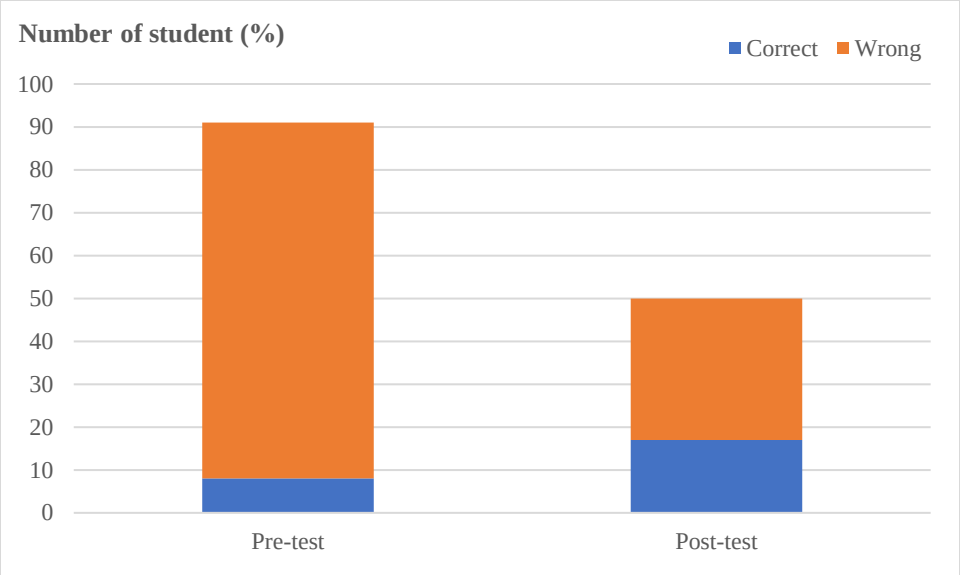

Figure 2 student who used the optical path difference to solving problem with correct and wrong answer.

It can be seen in pre-test that few students with OPD could find the answer correctly. On the other hand, almost half of the students who used the optical path difference gave the correct answer in post-test. Therefore, it could be concluded that teaching the concept of the OPD by using the activity sheet tend to help students to get more correct answer.

CONCLUSION AND FUTURE WORK

Firstly, the percentages of students giving correct answer in the pre-test and post-test on overall was examined. It was found that there is a jump of the percentage of students who gave the correct answer from pre-test to post-test. The statistical analysis indicated that there was a significant difference between the percentages of students giving correct answer between pre-test and post-test. Secondly, the class average normalized gains (<g>) were calculated. It was found that the normalized gains were at the low level. It can be concluded that the activity sheet could help improve students' understanding in double-slit interference.

In addition, the results of a thorough analysis also showed that the number of students who used the concept of the optical path difference in solving problem is obviously increased after learning with the activity sheet. It was also found that more than half of the students who used the OPD approach could reach the correct answer. It is implied that teaching the optical path difference with the activity sheet could help students apply the OPD concept during solving the problem about double-slit interference.

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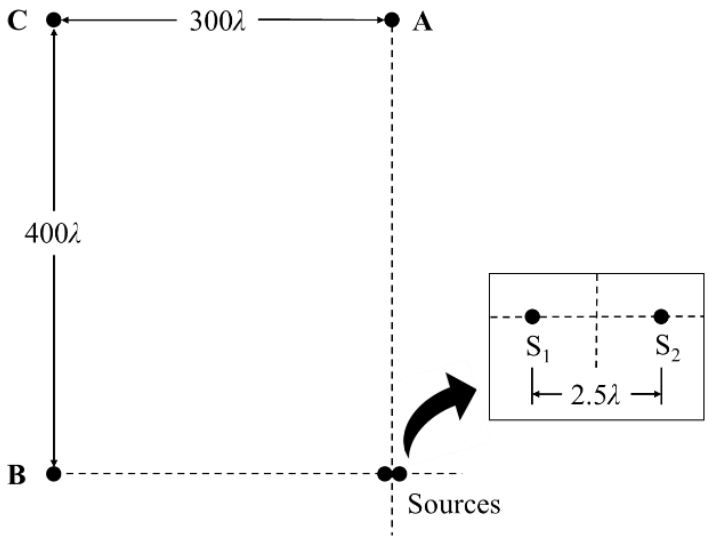
APPENDICES

Pre-test and Post-test

Problem: Two coherent sources S_1 and S_2 separated by 2.5λ emit light waves with the same phase. What is the type of interference (Constructive or Destructive) at each point (A, B, C).



Space for showing how to solve the problem or explaining the reason

Point A

Answer: Type of interference: _____

Point B

Answer: Type of interference: _____

Point C

Answer: Type of interference: _____