

PINE-ZODIAC: Methods of Mastering Ray Diagrams for Convex Lens Among Students of Kolej Vokasional Seri Manjung

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Abstract

This study was carried out due to the concern of the researchers after observing the students' poor performances in mastering the ray diagrams for convex lens involving various positions of objects and the impact on changes in the position of images, characteristics and examples of optical equipment. The objectives of the research are to increase students' performance in this topic, to attract students' interest in learning a difficult topic, and to develop interesting and effective Teaching Aids. The study was conducted on 40 students in the second year of the Sijil Vokasional Malaysia (SVM) at Kolej Vokasional Seri Manjung. This study involved the technique of drawing convex lens ray diagrams using the Pine- Zodiac (PZ) Technique as well as the use of PZ model. Research methodology used is the Kemmis & McTaggart model (1988) through Pre and Post-test instruments, interviews and surveys. The PZ Technique is used as an intervention. Statistical analyses were performed using SPSS 27.0 software. Significant differences pre- and post- intervention were determined using t-Test while significant difference in groups were determined by Spearman Test for the Likert Scale, with significance accepted at $p < 0.05$. The higher mean score after using the PZ technique which is 58.325. In conclusion, the PZ Technique is really beneficial for both students and teachers as students' achievement can be enhanced, students' confidence can be increased, and the Teaching Aids alternative. Hence, this technique can be developed through blended-learning involving face-to-face and virtual lesson in the future.

Keywords: Convex Lens; Pine-Zodiac; Ray Diagrams.

1.0 Introduction

The researchers are the lecturers of Sijil Vokasional Malaysia (SVM) Science subject at Kolej Vokasional Seri Manjung, Perak. Light and Optics is the final topic in the SVM Science Semester 3 course which involves the formation of images by lenses and optical equipment. The topic is a difficult topic to comprehend for the students. It is a crucial and critical topic because it is frequently asked in Final Assessment. According to years of experiences in marking students' answer scripts, the researchers have found that most students commonly failed to answer questions from this topic appropriately, in fact many did not even answer the questions by leaving them blank. As a result, students tend to lose a lot of marks due to this issue. This is because the question about ray diagram is included in Section B which is a compulsory part to be answered in the paper, where one question carries five (5) marks. This situation clearly shows that the students were not able to master the Light and Optics topic appropriately.

The issue of students failing to master the topic has led to a preliminary observation of this research. Data is obtained through observation of students' answers on tutorial exercises and interview sessions with the students who faced difficulties in understanding the topic. The results of the survey from the tutorial answers found that students failed to identify the correct position of the image due to confusion in understanding variety types of object position learnt in class, confused about the characteristics of the image, and were unable to remember the examples of optical equipment correctly.

The researchers also conducted unstructured observation while teaching this topic in class by focusing on the behaviors of students and body languages. The students seemed very stressed as they faced difficulties to understand the position of the object and subsequently had to draw the image formed based on the position of the object. They were several students who did not even draw the image which left their papers blank. Moreover, some students were trying to find the answers from their classmates. Unfortunately, the classmates were also facing the same issues and were unable to give the correct answer. One of the students also responded, "I am afraid to draw". As a result, the researchers felt uncomfortable and worried about the situation. They realized that this issue will be continued and perhaps become worse if some approaches to improvements are not taken. Therefore, the researchers had discussions to overcome this problem.

Table 1: Analysis of tutorial marks in Preliminary Test

Students Marks	Grade	Quantity and Percentage
80 -100	A (Excellent)	1 (3%)
60-79	B (Good)	6 (15%)
40-59	C (Satisfactory)	8 (20%)
0-39	D (Weak)	25 (63%)

Based on the discussion, an analysis was carried out to identify the interventions that need to be conducted. The results of the preliminary observation conducted towards students are as presented below. The score analysis for tutorial answers (Table 1) indicates 3% Excellent, 15% Good, 20% Satisfactory, and the majority of 63% Weak.

Table 2: Result of Students' Interview for Preliminary Test

Problems Statement	Percentage
1. Students confused in drawing the right position of image.	63%
2. Students didn't draw the image correctly.	28%
3. Students couldn't explain the position of image.	53%
4. Students couldn't list down the characteristics of image.	80%
5. Students couldn't remember the example of optic instruments correctly.	75%

Meanwhile, findings of the interview conducted with the students (Table 2) summarize common issues faced by the students to acquire this topic. It shows that 80% of the students were unable to list characteristics of the image and 75% of them could not remember the optical equipment correctly. Other than that, 63% of the students were confused in drawing the correct image, while 53% of them did not manage to state the correct position of the image. Thus, the researchers have thought about the PZ Technique and built a PZ model to increase students' understanding about the topic. Hence, PZ model is chosen by the researchers as one of the Teaching Aids in facilitating the students' understanding about the topic.

2.0 Methodology

Researchers used the Kemmis and McTaggart model (Figure 1) in this action research. This model involves four steps in each cycle which are planning, acting, observing, and reflecting.

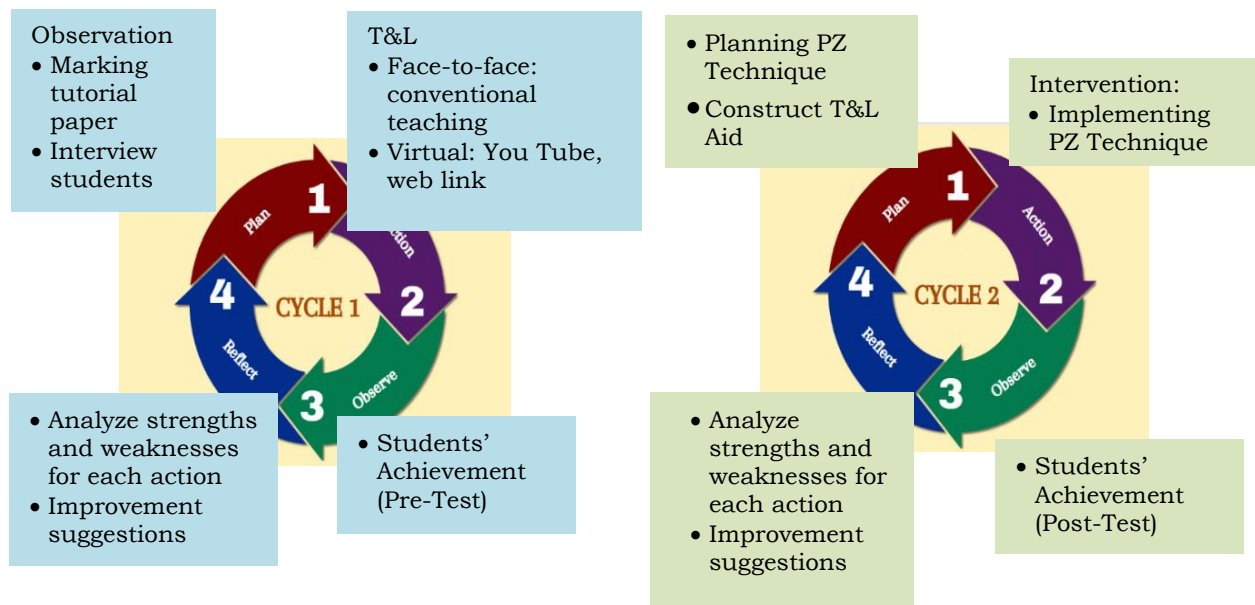


Figure 1: Kemmis and McTaggart Model (1988)

2.1 Sample size

The population of this study is students from the Electrical Technology and Electronic Technology programs at Kolej Vokasional Seri Manjung, Perak. The respondents are comprising of students from Semester 3 Sijil Vokasional Malaysia for 2023/2024 session. Based on Krejcie and Morgan (1970) table, the sample size for population of 140 is 103. The population of this study is 142 while the sample chosen is only 40, by focusing the third step in Cycle 1 of Kemmis and McTaggart Model (1988) which aimed the students who failed the preliminary test. The selection of classes is random.

2.2 Teaching and Learning Process

Pine-Zodiac is a method of teaching by implementing the use of Pine-Zodiac Model (Figure 2) during Teaching and Learning session. To explain these concretely, pine trees are used in the model that will change from one position to another. Thus, students need to determine the correct position of the pine tree image.

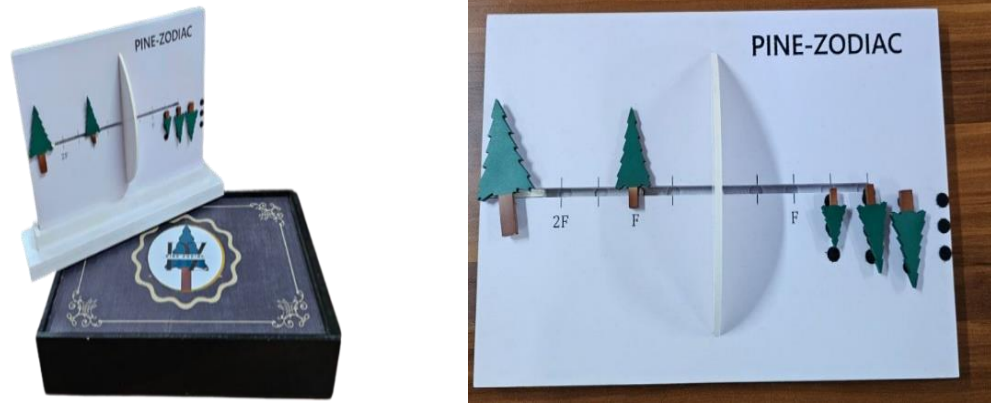


Figure 2: Pine-Zodiac Model

The set of sketches (Figure 3) together with the interesting mnemonic type acrostic technique (Figure 4) is very practical to facilitate students in recalling this technique while answering their Final Assessment. The demonstration (Figure 5) showed the two-ways interaction in the class.

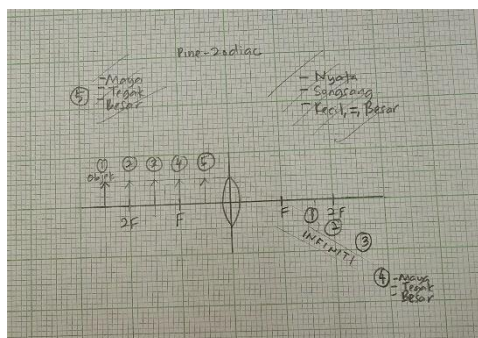


Figure 3: Sketching of Pine-Zodiac acrostic

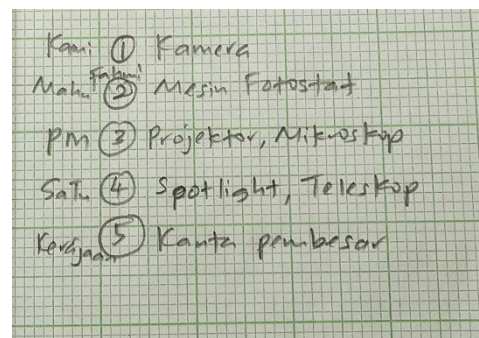


Figure 4: Mnemonic type acrostic



Left



Right

Figure 5: Movement of the object by the teacher as the question (left) and movement of the image by the students as the answer (right).

2.3 Research Instruments

The research instrument to collect the data of students' achievement is in the form of a test to compare their achievement before and after the PZ Technique is introduced. Pre-test is conducted in Cycle 1, which is after face-to-face and virtual Teaching and Learning session (before the PZ Technique was introduced). While, the Post-test is conducted in Cycle 2 after the students are introduced to the PZ Technique as an intervention.

The research instrument used to measure the effectiveness of the PZ Technique is based on table by Bahagian Perancangan dan Penyelidikan Dasar Pendidikan (2006). It was a Questionnaire with 10 questions (Table 1) created in the Google Form by including a 5-points Likert scale adapted from Salwati (2008) which are 1: Strongly Disagree; 2: Disagree; 3: Neither Agree nor Disagree; 4: Agree; and 5: Strongly Agree.

Table 1: The mean score for students' achievement through the Post-Test

Question	Subject	Mean	Level
1	Science is an easy subject.	4.18	High
2	I prefer to use other techniques other than PZ Technique.	2.85	Moderate
3	Light and Optics appears to be an easy topic even without Pine-Zodiac Technique.	3.00	Moderate
4	I easily understood ray diagram after the teacher introduced Pine-Zodiac Technique.	4.63	Very High
5	I easily memorized the ray diagram after the teacher introduced Pine-Zodiac Technique.	4.45	Very High
6	I feel interested in drawing ray diagram using the Pine-Zodiac Technique.	4.58	Very High
7	I was able to redraw the ray diagram using the Pine-Zodiac Technique.	4.50	Very High
8	I was confident to guide my friends to draw ray diagram using the Pine-Zodiac Technique.	4.18	High
9	The Pine-Zodiac Technique helped me in answering the Light and Optics questions in the examination.	4.60	Very High
10	I was certain to answer all questions about ray diagrams in the examination.	4.43	Very High
Average		4.14	

2.4 Statistical Analysis

The results obtained were expressed as mean \pm Regression Analysis. Statistical analyses were performed using SPSS 27.0 software (SPSS Inc., USA). Significant difference pre and post intervention were determined using t-Test while significant difference in groups were determined by Spearman Test for the Likert Scale, with significance accepted at $p < 0.05$ (Chua, 2008).

As stated by Chua (2008), Alpha Cronbach's values between 0.65 and 0.95 are acceptable. The reliability test for this study is ranging from 0.69 to 0.81, with the Alpha correlation is 0.75. Thus, the questionnaire for this study is acceptable.

3.0 Results and Discussion

The number and percentage of respondents based on programs are as follows: Electric Technology is 15 (37.5%) and Electronic Technology is 25 (62.5%). For male, is 33 (82.5%) and female is 7 (17.5%). Based on race, Malay is 37 (92.5%) while Indian is 3 (7.5%). It shows that the higher of respondents are from Electronic Technology program compared to Electric. The number of male respondents is higher than female. In addition, most of the respondents are Malay, while minimum is Indian and no other races are involved.

3.1 Results and Discussions of Research Objective 1

Improving students' achievement in mastering convex lens ray diagrams through the Pine-Zodiac technique.

The research result is significant ($t = -17.205$, $df = 39$, $p < .05$). The findings showed that there's difference of achievement in mastering convex lens ray diagrams before and after using the PZ technique. The higher mean score after using the PZ technique (Table 2) which is 58.325 showed that the PZ technique had increased the students' achievement.

Students were able to accumulate the movement of object's position and how to gradually relate the resulting image. Thus, this will resolve the students' confusion about the formed image criteria that consists of three aspects which are size, position and characteristics (Nur, 2023). Image formation by lens is a sub-topic that requires teachers to use their own skills to deliver appropriate understanding about the topic among the students (Ramzi, 2022) prompting the construction of PZ Technique which is proven its ability to increase students' achievement. It becomes very important in geometric optics by mastering the representation diagrams. Thus, the laws of physics will be delivered correctly when using the correct picture representation (Poluakan, 2019).

Table 2: Result of students' achievement as before and after using the PZ Technique

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre - Post	-58.325	21.440	3.390	-65.182	-51.468	-17.205	39	0.000

3.2 Findings and Discussion of Research Objective 2

Increasing students' participation during the Teaching and Learning Process.

Findings were measured from responses for question 6 and 8 in questionnaire instruments distributed to the students. Based on the result in Table 3, we can state that interest using the PZ technique and confident to guide friend using it have a significant linear relationship ($r=0.613$, $p<0.01$). The direction of the relationship is positive, meaning that these variables tend to increase together, which is greater interest is associated with greater confident.

The result indicates that the cognitive aspect (knowledge) of the students has increased and they were confident to answer this type of question. Students were actively and positively involved in the Teaching and Learning Process. This shows that teachers' expectation was not foiled where this research indicated PZ technique successfully maximize students' participation in the classroom. All students were interested to draw the ray diagram is a big change from previous situation where some students were unwilling to even try it and only some would try. So that the majority of students were emotionally positive and ready for peers-to-peers learning so that knowledge can be shared together.

The findings proved that students with positive emotions will be more mentally prepared to face Final Assessment. Emotional intelligence in the field of education consistently shows a positive relationship between emotional intelligence and academic performance (Alifah, 2012). They enjoy an exciting learning environment with their friends, achieve learning objectives for self-improvement and are willing to share with friends, as well as being able to apply PZ Technique to answer questions related to Light and Optics.

By applying this technique, teachers also successfully overcame reticence among students while teaching Light and Optics topics. Excellent students were able to comprehend the topic well by using this technique, hence they could conduct peers-mentoring with the weak students. Therefore, all of the students were able to understand the topic and apply it in answering exam questions despite their diverse learning profiles. One of three representations

that physics educators agree is correct drawing of light rays through lenses such as the ray diagram, other than conceptual knowledge and mathematical understanding (Danilo & Junehee, 2022)

Table 3: Findings of Questionnaire Analysis (Item 6 and 8)

Correlations			
		I was confident to guide my friend to draw diagram using the Pine-Zodiac Technique	
Spearman's rho	I feel interested in drawing ray diagram using the Pine-Zodiac Technique	Correlation Coefficient	.613**
		Sig. (2-tailed)	0.000
		N	40
**. Correlation is significant at the 0.01 level (2-tailed).			

3.3 Findings and Discussion of Research Objective 3

Producing Interesting Teaching Aids for Light and Optics module.

Findings were measured from the responses for question 4 and 5 in questionnaire instruments distributed to the students. Based on the result in Table 4, we can state that understanding and memorization after using PZ Technique have a significant linear relationship ($r=0.703$, $p<0.01$). The direction of the relationship is positive, meaning that these variables tend to increase together, which is greater understanding is associated with greater memorization.

The findings showed that students liked the Teaching Aids used in this technique and were able to understand the ray diagrams easily. Thus, made it easier for the students to remember the correct ray diagram. The shape of the Teaching Aids turned out to have a great positive impact on the students because through them, students were able to draw ray diagrams, images, and state the characteristics of the resulting image (Omar, 2019). Teaching Aids used in the PZ Technique also supports differentiated pedagogy as researchers emphasize four main elements, contents, processes, products and environment. These elements are combined according to the diversity of pupils in terms of readiness, interest and learning profile (Zurina et al., 2021).

This Teaching Aids product facilitated the students in answering their Final Assessment, attracted their interest in learning difficult topics, and created a positive learning profile which refers to the most effective learning style among the students to the extent they were capable to teach their friends regarding the topic.

Table 4: Findings of Questionnaire Analysis (Item 4 and 5)

Correlations			
			I easily memorized the ray diagram after the teacher introduced Pine-Zodiac Technique
Spearman's rho	I easily understand the ray diagram after the teacher introduced the Pine-Zodiac Technique	Correlation Coefficient	.703**
		Sig. (2-tailed)	0.000
		N	40
** . Correlation is significant at the 0.01 level (2-tailed).			

4.0 Conclusion

This teaching aid can be used in Teaching process by lecturers of Kolej Vokasional in semester 3 SVM and teachers in secondary school who teach Physics or Science for SPM. The PZ Technique allows the instructors to use it as an interesting Teaching Aid in the classroom, and the combination of sketches with mnemonics is practical for the students to easily remember to be applied while answering the Final Assessment. It will encourage students to sketch PZ Techniques more creatively and complemented by mnemonic-acrostic technique. The impact had been proved by the data of pre and posttest of students' achievement.

The researchers hope that the PZ method will be able to facilitate students in understanding and mastering this Light and Optics topic. This research confirms the effectiveness of the technique in improving students' achievement in mastering the ray diagrams of convex lenses. It is highly recommended to implement this technique in Teaching and Learning session to improve students' understanding and to increase their ability to remember for Light and Optics topic. It is believed that students will have the ability to answer this topic well in their Final Assessment.

Other than that, students fully dependent on teacher is another challenge for the teachers whereby they need to increase students' motivation in mastering the technique. Accordingly, researchers suggest the teachers to implement repetition during the teaching process of this Light and Optics topic. This effort can encourage the students to practice more with a better understanding until they successfully become independent learners.

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Author Contributions

M. M. Muklas: Abstract, Introduction, Data collection, Writing-Reviewing; **Z. A. M. Desa:** Conceptualization, Methodology, Data collection, Result; **S. M. Jisin:** Discussion, Writing-Reviewing, Editing; **K. A. Khalid:** Discussion, Writing-Reviewing, Editing.

Conflicts Of Interest

The manuscript has not been published anywhere else and is not being considered by any other journals. All authors have authorized the review, agree with the submission, and state they have no conflicts of interest in the work.

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