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Polarization of Light Experimental Kit: New Design

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ABSTRACT

Polarization is an important property of light that has numerous applications in science and technology. It refers to the orientation of the electric field vector of a light wave as it propagates through space. Polarization is one of the topics that have been taught in the Foundation Physics course. Time constraints and a lack of appropriate laboratory apparatus are the two main reasons why this topic is only being taught theoretically, making it difficult for students to grasp the concept. Due to these constraints, a group of physics lecturers at the Centre of Foundation Studies UiTM Dengkil introduced and developed a simple experimental kit called the "Polarization of Light Experimental Kit" as an initiative to help students' understanding by visualising the polarization process. This kit is portable, mobile, and easy to handle. Thus, it will attract students' interest and serve as an interesting hands-on activity for them. A preliminary questionnaire survey was distributed to Foundation Science and Engineering students at UiTM Dengkil back in 2017 to assess their understanding on the polarization concept before and after using previous design of this experimental kit in their learning process. From the analysis, about 58% from 120 students agreed that this experimental kit was able to enhance their understanding on polarization of light concept and their interest in learning Physics. The design of this kit is being improvised to make it more practical and attractive to be marketable. Recently, a new survey has been distributed by introducing our new design of the Polarization of Light Experimental kit to a sample of 126 foundation students at Centre of Foundation Studies to assess their understanding on the polarization concept before classroom session, during classroom session and after using the new design experimental kit in classroom learning process. From the analysis, the percentage of the students that agreed the new design experimental kit gave them a better impact on enhancing their understanding and interest on polarization of light concept has increased to 70%. This experimental kit has a high potential to be commercialized as a useful teaching aid for educators and students who want to gain a deeper understanding of the polarization of light concept and its applications.

Keywords: Polarization of Light; Polarized Light; Experimental Kit

INTRODUCTION

Polarization of light is a fascinating phenomenon that is widely observed in our daily lives. It occurs when light waves vibrate in a single plane instead of in all directions, which results in the creation of a polarized light wave. The study of polarization of light has many practical applications in fields such as optics, telecommunications, and astronomy. Since teaching a physics theory without a proper introduction of mathematical tools such as matrices, vectors and complex numbers is a problem [1], and if physics is taught solely through the lecture method, students will only understand formulas or abstract concepts [2].

Although there are studies on students' difficulties with wave optics concepts and phenomena [3–6], it primarily focuses on light interference and diffraction. Fewer studies discuss the understanding of students on the light polarization published. The same problem occurs for foundation students at Centre of Foundation Studies in UiTM, when the polarization topic only being taught theoretically due to limited time and unavailable of proper experimental tools. Thus, students rarely understood the concept without experiencing the phenomena themselves.

As knowing the benefit of teaching aids usage in learning provide opportunities for students to be active in learning, allowing them to gain knowledge and develop psychomotor skills, as well as foster student creativity to solve problems encountered [7–8], a physics lecturers' innovation team at Centre of Foundation Studies, UiTM has developed an interactive, portable and cost effective polarization of light experimental kit for quantitatively verifying the nature of polarized light.

INNOVATION DEVELOPMENT

First and foremost, this polarization of light experimental kit has gone through three phases of improvisation from 2016 to 2022. This kit was invented from scratch in 2016 by using a kitchen paper roll as the main body and the adjustable rotation part with drawing angle scales. The polarizer used was the polarized sunglasses. In 2018, the fragile body and adjustable rotation part of the kit were being replaced by the PVC pipe with addition of a lux meter as the measured intensity of light tool. A survey has been done to collect students feedback based on their experience using this kit as a learning aid in classroom. Based on the feedback, this kit evolved to become the latest 3D printed design with 15-degree angle scale with stands, set of polarizer sheets and a lux meter. This latest design received a great impact on students' feedback. This kit has received medals for several innovation competitions and has been protected with Intellectual Property Recognition (IPR).

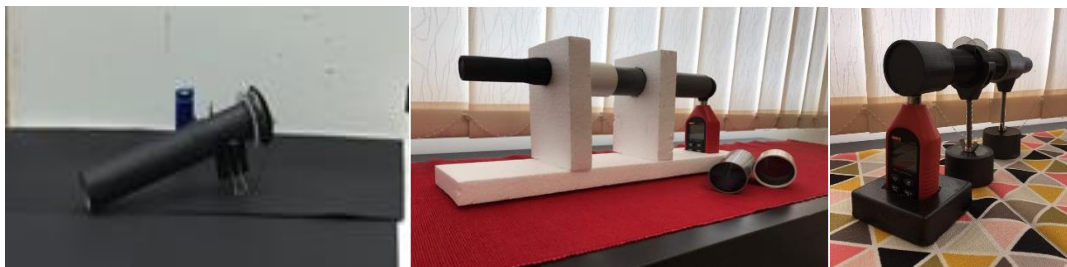


Figure 1: The revolution of the “Polarization of Light Experimental Kit” from 2016 to 2022

COMMERCIAL POTENTIAL

Polarization is one of interesting topic to be discussed in class. Due to its fascinating phenomenon that is widely observed in daily lives, students gained valuable knowledge and information from learning this topic. Because of time constraint while discussing the topic and lack of laboratory apparatus, students and lecturers must limit the extension knowledge regarding polarization. Thus, the students just comply the theoretical part. To make it interesting and help students grasp the theory, a polarization of light experimental kit was invented and thus developing a hands-on activity can give the students the real experience while learning the polarization topic in class. This Polarization of Light Experimental Kit was purposely designed to become portable and can be carried around easily. A telescope-like shape gives the outlook

more practical to be handled. Furthermore, much easier to look through the light intensity in various angle. Hence, the knowledge also covered most crucial theory in polarization topic which is Malus' Law. The material of telescope-like shape is made of thermoplastic aliphatic polyester (PLA). This material is fully biodegradable thermoplastic polymer. Therefore, it safe for environment. The designing process of the experimental kit is easy and affordable. The whole component of the main body was printed by 3D-printer. The polarizer is a customize polaroid sheet so that it can be used for several polarizers. The polarization of light topic is included in physics' syllabus. However, the topic just small part in the lesson plan and there is no experiment conducted for the topic. Due to this circumstances, polarization of light experimental kit is a new solution to deliver this topic interestingly in class. Other than help students understanding, this kit succeeded to gain students interest in learning polarization of light. This kit is practical, attractive, and affordable. It has a high potential to be commercialized. This kit is ready to be in the market and already protected with IPR.

Figure 2 shows the set-up of the polarization of light kit that consists of 2 polarizer sheets, 3 stands, 3—D printed adjusting rod with 15-degree angle scale, a lux meter as the light intensity detector and torchlight as a light source.



Figure 2: The “Polarization of Light Experimental Kit: New Design”

Table 1 shows the result of the intensity of light detected by the lux meter. Table 2 shows the result of the intensity of light observed by bare eyes.

Table 1: The intensity of light detected by Lux Meter

Angle of the 1st polarizer	Angle of the 2nd polarizer	Intensity of light (lux)
0°	0°	Maximum Intensity: ± 38
0°	90°	Minimum Intensity: 0
0°	0° < θ < 90°	0 < intensity < 38

Table 2: The intensity of light observed by Bare Eyes

Angle of the 1st polarizer	Angle of the 2nd polarizer	Intensity of light
0°	0°	Maximum Intensity: Bright
0°	90°	Minimum Intensity: Dark
0°	0° < θ < 90°	Reducing intensity: less bright

CONCLUSION

In a nutshell, the polarization of light experimental kit is successful in achieving all the objectives of the product appearance. In the future, the product will be completed with smart polarizer slit and various angle's marker. Furthermore, this product is recommended to be used in foundation studies as a complementary teaching aid as hands-on activity in the class. As for future planning, the kit is going to be provided by the method to apply for Malus' Law.

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