Designing At-Home Experiment on The Inverse Square Law of Light during Pandemic: An Action Research

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Abstract: We designed an at-home experiment on the inverse square law of light as an alternative to a standard in-campus experiment during the COVID-19 pandemic. The collaborative experiment uses smartphones with remote instructor's support.

1. Introduction

The World Health Organization (WHO) declared the outbreak the COVID-19 pandemic on 11 March 2020. In response to the call, Malaysia enforced the Movement Control Order (MCO) nationwide in 18 March 2020. Under this regulation, all educational institutions were closed. This sudden situation demanded a change in a curiculum delivery.

Vibrations, Waves and Optics (VWO) is a course offered to teacher trainees at Sultan Idris Education University. The teacher trainess enrolled in Bachelor of Education program in Science and Physics. One of the outlined course learning objectives is "to perform laboratory exercises and report writings". The course was in the middle of semester at time of the enforcement was announced, which was on week 5 out of 14 weeks of face-to-face session. Therefore, an alternative assessment to achieve the learning objective must be designed to avoid learning progress. A series of at-home experiments was quickly designed to fulfil the learning objectives. One of such experiments is the inverse square law of light.

2. Action Research

When we planned the experiment, the main concern was "How can we support student experiment effectively to achieve learning objective in the new norm of learning?". At that time of planning, we do not know when the pandemic will be over. At the time of writing this article (June 2021), our university is still running on the off-campus mode. Curriculum delivery is made mainly via on-line method.

We embraced action research based on McNiff model to guide our instructional practice [1]. The model involves six processes: Observe – Reflect – Act – Evaluate – Modify – Move in new directions. This cyclic process is also generally known as the action-reflection cycle. We describe the process in the following subsections.

2.1 Observe

Due to the sudden change in curriculum delivery, we had a very short time to design the experiment. Several challenges were taken into consideration. (1) Smartphone usage for science activity measurement. (2) Resource availability (3) Time allocation. (4) Method of assessment. Generally, a standard in-campus session for a work takes at least two hours in a collaborative group of four students under instructor supervision. The lab work involves the same sets of instruments and apparatus. Students must submit their report a week after the lab session.

2.2 Reflect

Based on the identified limitations, we reflect on our practice for the new norm. We believed that a simplified version of a standard experiment using available resources at home could be an alternative for students to fulfil learning objectives. While some instructors opt for using computer simulation to replace labwork, we think doing real experiments is essential to prove and grasp physical concepts. [2]

2.3 Act

We designed a simple experiment to relate the light intensity at a point and the distance of the point from the light source using a smartphone. Modern smartphones are equipped with various sensors usable for science experiment such as sound sensor using microphone, light sensor using ambient sensor and video tracking analysis using camera [3]. The submitted report must consist of standard lab report components (abstract, introduction, methodology, analysis, conclusion) in pdf form. To get an insight into what they feel about the task, we required students to add a

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component: reflection. This component allows us to access room for improvement in our instructional delivery. The at-home experiment was a group task. Therefore, students work collaboratively with geographically apart. On-line communication is the primary mean to make them together. Five weeks were given for the task accomplishment. We support them asynchronously by text, image, voice, or video message that student leaves to us during the period.

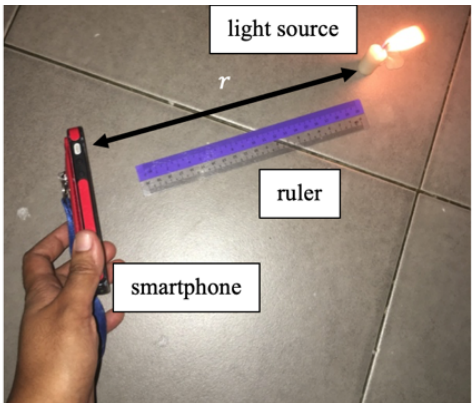

Fig. 1. Experiment with the inverse square law for light using a smartphone.

2.4 Evaluate

After the submission period, we summarize key observation to improve our instruction.

(i) Smartphone : The experiment uses the ambient light sensor on the smartphone front to measure the intensity of a light. Two main groups of smartphone users, iPhone and an Android users. iPhones uses the unit of EV (Exposure Value) in the light measurement app while the later uses lux (lx).

(ii) Light source : Some students use light source of an array of LEDs. These is common modern devices such as torchlight and smartphone light.

(iii) Apps : We initially encourage to use Google Science Journal. This app is available for both iOS and Android users. However, this apps migrated to Arduino Science Journal. This migration cauased confusion to us.

(iv) Environment : Some students reported a large deviation from the inverse square law. We found that the made wrong fitting of the graph they plotted. Most students thinks that all physical parameter has linear relationship.

2.5 Modify

Based on the observations reported above, we made some modification to our instruction.

(i) We made a video to explain the relation between EV, lux and the intensity light. The note about this is also included in the newer version of at-home experiment instruction.

(ii) We suggest students to use a spherically single light source, preferably a candle. We encouraged students to make observation under controlled condition. Avoid floor surface reflection and stray light.

(iii) We propose the use of Physics Toolbox app. Other apps are also possible. Usually, students will make confirmation with if they use other apps.

(iv) We produced an instructional video to fit the graph using a spreadsheet.

2.6 Move in new directions

In the second semester of the implementation of the at-home experiment, we received less technical questions from student. Two cycles of action-reflection had fulfilled our concern. The report that students submitted were in higher quality, based on the graph they plotted and data analysis they reported. We were satisfied that students can perform their task with minimum remote supervision form us. The experience we gain in designing this experiment is useful to improve our instructional strategy in conducting a remote experiment.

3. References

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