DEVELOPMENT OF THE SMARTPHONE-BASED LEARNING MODULE EXPERIMENT ON THE APPLICATIONS OF PHOTOELECTRIC EFFECT AND ITS USABILITY AMONG PHYSICS TRAINING TEACHERS

MUHAMMAD FAHMI BIN AMAYAH

SULTAN IDRIS EDUCATION UNIVERSITY

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Abstract

This study focuses on developing a smartphone-based learning module on the Photoelectric Effect for Physics trainee teachers. The sample consists of 52 semester-7 UPSI Physics trainee teachers selected through simple random sampling. The module was developed using the ADDIE model, encompassing analysis, design, development, implementation, and evaluation phases. Instruments for the study included face and content validity assessment forms and a usability questionnaire. Expert validation, conducted by two Physics lecturers and a school teacher with over five years of teaching experience, confirmed a high content validity score of 1 using CVI. Usability data were analysed through SPSS, yielding frequency, percentage, mean, and standard deviation values. Reliability analysis of the module, based on a pilot study, revealed a Cronbach's Alpha value of 0.8. Usability constructs demonstrated good levels: perceived usefulness (mean = 3.801, s.d = 0.39), ease of use (mean = 3.786, s.d = 0.424), ease of learning (mean = 3.763, s.d = 0.466), and satisfaction (mean = 3.796, s.d = 0.399). These findings suggest the module effectively meets its objectives where it gives implication in enhancing pedagogical skills, particularly in integrating technology into teaching practices.

Pembangunan Eksperimen Modul Pembelajaran Berasaskan Telefon Pintar terhadap Aplikasi Kesan Fotoelektrik dan Kebolehgunaannya di kalangan Guru Pelatih Fizik

Abstrak

Kajian ini memfokuskan kepada pembangunan modul pembelajaran berasaskan telefon pintar mengenai Kesan Fotoelektrik untuk guru pelatih Fizik. Sampel terdiri daripada 52 orang guru pelatih Fizik UPSI semester-7 dipilih melalui persampelan rawak mudah. Modul ini dibangunkan menggunakan model ADDIE, merangkumi fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Instrumen kajian termasuk borang penilaian kesahan muka dan kandungan serta soal selidik kebolehgunaan. Pengesahan pakar, yang dikendalikan oleh dua pensyarah Fizik dan seorang guru sekolah yang mempunyai pengalaman mengajar lebih lima tahun, mengesahkan skor kesahan kandungan yang tinggi iaitu 1 menggunakan CVI. Data kebolehgunaan dianalisis melalui SPSS, kekerapan menghasilkan, peratusan, min, dan nilai sisihan piawai. Analisis kebolehpercayaan modul, berdasarkan kajian rintis, mendedahkan nilai Alpha Cronbach sebanyak 0.8. Konstruk kebolehgunaan menunjukkan tahap yang baik: dirasakan kebergunaan (min = 3.801, s.d = 0.39), kemudahan penggunaan (min = 3.786, s.d = 0.424), kemudahan pembelajaran (min = 3.763, s.d = 0.466), dan 6 = kepuasan, s.d = 0.399). Dapatan ini mencadangkan modul ini memenuhi objektifnya dengan berkesan di mana ia memberi implikasi dalam meningkatkan kemahiran pedagogi, terutamanya dalam mengintegrasikan teknologi ke dalam amalan pengajaran.

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LIST OF ABBREVIATIONS

ADDIE	Analysis, Design, Development, Implementation, Evaluation
PhET	Physics Education Technology
DSKP	*Dokumen Standard Kurikulum dan Pentaksiran*
SPM	*Sijil Pelajaran Malaysia*
UPSI	Sultan Idris Education University
CE	Concrete Experience
RO	Reflective Observation
AC	Abstract Conceptualization
AE	Active Experimentation
POGIL	Process-oriented Guided Inquiry Learning
KSSM	*Kurikulum Standard Sekolah Menengah*
CVI	Content Validity Index
SPSS	Statistical Package for the Social Sciences

APPENDIX LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

Science is at the heart of understanding the world around us, and subjects like Physics, Biology, Mathematics and Chemistry play a key role in equipping students with the knowledge and skills to navigate and contribute to an ever-changing world. In Malaysia, the *Kurikulum Standard Sekolah Menengah* (KSSM) emphasizes the importance of these subjects, not just for academic success but for nurturing critical thinking, problem-solving, and curiosity about the natural and technological world. These subjects form the foundation for students to explore the wonders of science and its applications in real life.

Over the past few years, educational technology has transformed how STEM content is delivered in classrooms. Tools like smartphones, educational apps, and online platforms are becoming increasingly common in Malaysian schools, driven by the momentum of the Fourth Industrial Revolution (IR 4.0). In science education, these technologies have the power to bring abstract concepts to life, allowing students to conduct virtual experiments, explore interactive simulations, and connect classroom lessons to real-world applications. Life-relevant learning environments, supported by mobile apps and technologies, help students see the connection between scientific concepts and their daily lives, making science more engaging and meaningful. (Clegg et al., 2012)

1.2 Research Background

Mastery of scientific skills in science subjects, especially physics, is very necessary to study and solve problems and make decisions systematically. Physics experiment activities offer numerous benefits to students. They enhance understanding by providing a hands-on approach to learn, making complex concepts more tangible and easier to grasp (Januaris, et.al., 2022). The photoelectric effect in Physics Education is one of the topics that have been highlighted as a crucial concept where it's illustrates the quantum nature of light and its interaction with the matter. Traditionally, experiments on the photoelectric effect need a complicated and sophisticated equipment, where it can be a barrier for many secondary schools and the teachers. Additionally, physics experiments play a crucial role in motivating students, engaging

them actively in the learning process, and developing their critical thinking skills and physics related competences (Dominik, 2019). Thus, without a proper equipment for conducting an experiment for photoelectric effect, it can lead to many misconceptions and negative impact for students to mastery the scientific skills in physics.

Other than that, the recent developments in technology also paved the way for a more effective teaching of complex scientific concepts. Interactive and engaging learning experiences are being provided through digital tools and simulations. Moreover, based on Purwoko Haryadi Santoso (2022) in his research, the implementation of technological approaches such as level differentiation technology, allows for individualized learning experiences in physics education and catering to students' diverse needs and abilities at varying levels of complexity. Physics Education Technology (PhET) is one of the famous technology developments in physics education in the meantime. By utilizing PhET, it has been shown to significantly improve student's test results, with those using simulation tools scoring higher than those without (Ogi, 2023). Smartphones are incredibly powerful and widely available, making them a great tool for conducting scientific experiments in schools. Because they are portable and easy to use, smartphones have been used in many different areas of science to simulate complex experiments. Smartphones nowadays have been equipped with high-precision sensors, which have been utilized in physics undergraduate research and demonstrating their potential in fields like mechanics, acoustic, waves, magnetism and optics (Barro, 2023). In physics classes, for instance, the sensors and apps on smartphones can be used to carry out experiments that usually need special, expensive lab equipment. The studies by Edeh (2023) have demonstrated that incorporating smartphone-based experimental exercises in mechanics courses and have positively influences motivation, interest and conceptual understanding. By connecting

sensors to smartphones, a real time measurements and experiments can be conducted, where it is allowing students to explore physics concepts (Ryo, 2022). Thus, this approach not only makes scientific education more accessible to everyone but also supports the goal of helping students become more digitally literate in today's education systems.

1.3 Rationale of Study

The rationale for this study on the development and usability of a smartphone-based learning module experiment on the photoelectric effect in secondary school physics among training teachers in Malaysia is multi-sided, addressing both educational and technological needs within the Malaysian education system. Firstly, the photoelectric effect is one of the critical topics in Quantum Physics which demonstrates the particle character of light and interaction between the light and matter. Quantum Physics is a fundamental and challenging subject which has been introduced in the Malaysian secondary school (DSKP 2019). Yet, the resources and teaching aids needed to teach this course in a way that is beneficial for trainees remain scarce. Hence, to overview the gap of teaching resources, this study aims at developing a smartphone-based learning module that helps teachers teach using better and easily accessible methods to comprehend some abstract concepts. Secondly, the use of smartphones is possible at present hundreds of students and teachers have access to it. In this study, the implementation of the computational abilities and interactivity of smartphone devices to develop a low-cost and accessible learning intervention. In this manner, they are able

to take the most advanced scientific experiments, which would require prohibitively expensive laboratory equipment and implement them in any classroom quickly. In summary, this study is driven by the need to improve the teaching and learning of Quantum Physics in Malaysian secondary schools through innovative and accessible technological solutions. By addressing both educational and technological challenges, the research aims to contribute to better educational outcomes and prepare students and teachers for a future where digital literacy is paramount.

1.4 Problem Statement

Understanding the photoelectric effect poses challenges for students in school physics education (Jho et.al., 2023). This phenomenon, where light causes the emission of electrons from a material, involves complex concepts such as photon energy, electron emission thresholds, and the particle-like nature of light. Traditional teaching methods often rely on theoretical explanations and diagrams, which may not fully capture the subtleties of the photoelectric effect or engage students effectively (Evagorou et al., 2015). Additionally, hands-on experimentation with photoelectric setups can be challenging due to the need for specialised types of equipment and safety concerns. As a result, students may struggle to grasp the fundamental principles underlying the photoelectric effect, hindering their overall understanding of quantum physics concepts.

The swift advancement of technology offers new opportunities to revolutionize physics education such as physics mobile learning. However, there are some challenges

and problems that arise among the students which causing them to not fully utilizing the potential of mobile learning. They found that while mobile devices were primarily for communication, they found no association with research related to communication or collaboration (Sisda Ferlianti et.al., 2023). Students found the problem that their facing in conducting a remote lab experiment back when COVID-19 pandemic happened. Students faced challenges conducting lab experiments due to the COVID-19 pandemic.

In the realm of secondary school physics education, innovative approaches are crucial for effectively teaching fundamental phenomena like the photoelectric effect. Teachers may face challenges when conducting lab experiments when it comes to laboratories tool in schools. Teachers face issues conducting lab experiments due to limited facilities, lack of labs, and reliance on online demonstrations. Suggestions include increasing lab resources and providing practical training for teachers (Duban et.al., 2019). Moreover, when it comes to laboratory work the most important part is safety concern. Conducting a laboratory work requires a safety of surrounding and its tools, thus by utilizing a mobile physics applications can fulfil the barrier of those problems and make it easy for teachers conducting the experiment by using self-learning method for students.

1.5 Research Objectives

1. To develop an experiment using smartphone light sensor on the photoelectric effect in secondary school physics among training teachers.

2. To investigate the usability of the smartphone-based experiment on the photoelectric effect in secondary school physics among training teachers.

1.5 Research Questions

1. Is smartphone light sensor be effectively utilized to develop a smartphone-based experiment for teaching the photoelectric effect in secondary school physics among training teachers?

2. What are the perceptions by trainee teachers when using a smartphone-based learning module for teaching the applications of photoelectric effect?

1.6 Research Scope and Significances

This study is significance for a school, teachers, training teachers and form 5 students where the topic is limited to photoelectric effect which also included in big examination

(SPM). The development of smartphone-based learning module experiment in this study is to investigate the usability of the smartphone-based experiment on the photoelectric effect in secondary school physics among training teachers. The study encompasses a few significances particularly for students and training teachers.

i) Training teachers

This study is conduct to measure the module effectiveness in enhancing training teachers' understanding of the photoelectric effect. The newly introduced quantum chapter presents challenges, particularly the photoelectric effect subchapter, due to its complexity in physics education. Thus, a fresh method that needed to give teaching and learning medium to be more flexible and interactive besides giving an impact on training teachers' engagement and motivation to learn and teach the photoelectric effect. On top of that, the learning module is significant for improvement in pedagogical skills, certainly in the integration of technology into teaching practices in which can enhancing training teachers' ability to use digital tools in their future classrooms.

ii) Students

This study is also important for students who will take the big exam, namely Sijil Pelajaran Malaysia (SPM), especially for Form 5 students. The interactive design of the smartphone-based learning module makes learning about the photoelectric effect more intuitive and engaging. Instead of just reading it in a textbook, students can experience the learning and help bring the photoelectric effect concept to life. This hands-on approach helps students understand and remember the complex key concepts behind the photoelectric effect more easily. Other than that, when students use the smartphone-

based learning module, they get used to integrating technology into their daily learning. This positive experience with digital tools helps them se technology as a helpful part of the education. It is significant in builds their confidence in using technology for learning and makes them more adaptable and ready for future advancements

1.7 Conceptual Framework

A conceptual framework was serves as a foundational structure of interrelated ideas that describe, explain and predict a specific phenomenon, guiding the understanding and development of various fields. Based on study by Fernández & Leonardo Bermón Angarita (2022) in the university setting, a conceptual framework for research aids in enriching knowledge, improving individual and institutional productivity in research and enhancing research capabilities within the academic community. In this study, this conceptual framework for the development and usability of smartphone-based experiment on the photoelectric effect consist of several related components. This conceptual framework outlines the process based on the interrelated theories, instructional model that have been used and few phases of the module development as shown in Figure 1.1.

In this conceptual framework, learning theories that have been applied were constructivism theory, mobile learning theory and Kolb experimental theory which these three theories were interrelated components. ADDIE model has been chosen to be the instructional design models of this study. During the implementation phase, the

module was introduced to experts and training teachers to look over the module's validity. Finally, the evaluation phase towards the module, was executed by a test on a usability of the developed module through a questionnaire.

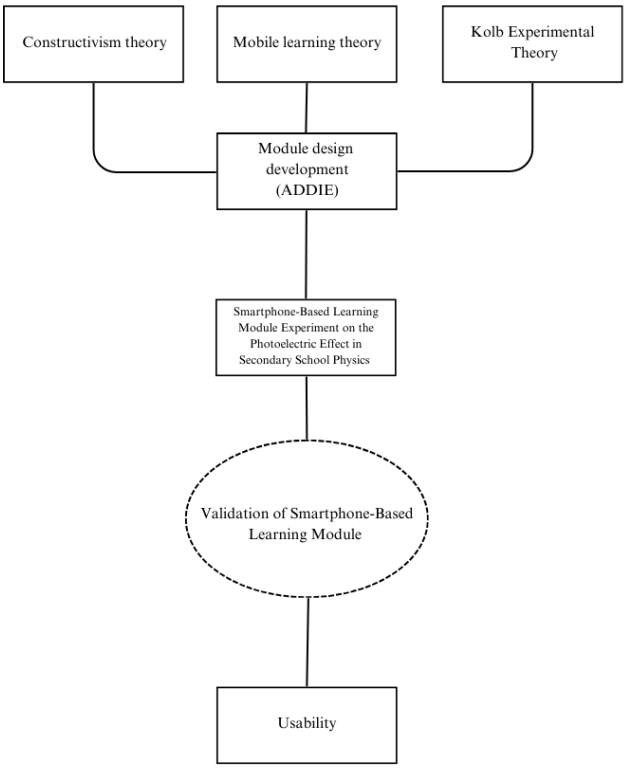

Figure 1.1. Research Conceptual Framework

1.8 Operational Definition

i) Development

The development of learning module involves creating structured educational materials that facilitate effective learning process Development refers to the structured process

of creating and refining educational programs, curricula, and instructional methods to improve teaching effectiveness and student learning outcomes. This process often involves research, design, implementation, evaluation, and continuous improvement. (Reiser & Dempsey, 2017). The process of the module development typically follows a systematic approach like the ADDIE model which includes stages as Analysis (A), Design (D), Development (D), Implementation (I) and Evaluation (E).

ii) Usability

According to (I. Yu. Mamedova et al., 2022), usability refers to a design object's quality enabling users to achieve goals effectively and satisfactorily, which also it is crucial for assessing product design quality in various contexts. In this context of this study, the usability of module is measured by questionnaire that adapted of Lund (2001) which initially focused on three important components, usefulness, satisfaction and ease of use. Each component has 5 construct that will be evaluated with Likert scale where it is started from strongly disagree, disagree, agree and strongly agree.

1.9 Limitations and Delimitations

i) Limitations

In spite of that, the development of the module is limit towards a subtopic of Photoelectric Effect where it consists in Form 5 Physics subject only. Additionally, this topic was recently introduced in the Curriculum and Assessment Standard Document 2019 (DSKP). As a consequence of that, this topic was selected because research on Quantum Physics, particularly in the development of teaching aids, is still underexplored among researchers in Malaysia. The development of smartphone-based learning module depended on participants having access to smartphones and being able to use them effectively. Since everyone had different smartphone models, operating systems, and varying levels of comfort with mobile technology, this could have affected how well the learning module worked for them. Additionally, practical issues like whether the app worked well on different phones, how easy it was to read on different screen sizes, and battery life were not specifically managed, which might have influenced their overall experience.

ii) Delimitations

In creating and testing the smartphone-based learning module for teaching the photoelectric effect in secondary school physics, the researcher made some specific choices to keep the research focused and manageable. These decisions help explain the context and limits of this study.

The delimitation of this study also covering to its respondent and region of the studies area. Considering the requirement of Physics as major subject teaching, training teachers who do not teach a Physics subject were eliminated from the research. In this context of study, a respondent who involved were among the teacher trainees in the field of Physics Education in Sultan Idris Education University (UPSI) which is

students who are in semester 7. The researcher chose this setting to keep things controlled and easier to manage. Because of this, the study findings are specific to this location and might not reflect what trainee teachers in other regions or different educational settings might experience.

1.10 Summary

This study on the development and usability of a smartphone-based learning module experiment on the photoelectric effect aims to enhance the teaching and learning of secondary school Physics in Malaysia. In a summary, Chapter 1 discussing about the introduction of the overall the study and the problem statement that have been a starting point to the implementation of this study. Other than that, this chapter also consists of objectives and questions that occur throughout the study. Then followed by research hypotheses, research scope and significances, conceptual framework, operational definition and ends with limitations. Overall, this research aims to use smartphone technology to make learning Quantum Physics easier and more effective for students in Malaysian secondary schools. By doing this, it hopes to improve the overall quality of education and help students better understand complex scientific concepts.