THE DEVELOPMENT OF A GEOMETRICAL OPTICS LEARNING MODULE (GOLeM) AND ITS USABILITY AMONG PHYSICS MATRICULATION STUDENTS

UMMI ATIAH BINTI MOHAMAD

SULTAN IDRIS EDUCATION UNIVERSITY
2021

THE DEVELOPMENT OF A GEOMETRICAL OPTICS LEARNING MODULE (GOLeM) AND ITS USABILITY AMONG PHYSICS MATRICULATION STUDENTS

UMMI ATIAH BINTI MOHAMAD

DISSERTATION PRESENTED TO QUALIFY FOR A MASTER'S DEGREE IN EDUCATION (PHYSICS) (RESEARCH AND COURSEWORK MODE)

FACULTY OF SCIENCE AND MATHEMATICS
SULTAN IDRIS EDUCATION UNIVERSITY
2021

UPSI/IPS-3/BO 32
Pind : 00 m/s: 1/1

UNIVERSITI PENDIDIKAN SULTAN IDRIS
SULTAN IDRIS EDUCATION UNIVERSITY

Please tick (√)

Project Paper	
Masters by Research	
Master by Mixed Mode	✓
PhD	

INSTITUTE OF GRADUATE STUDIES

DECLARATION OF ORIGINAL WORK

This declaration is made on the ......12.......day of.......10........20.21...

i. Student's Declaration:

I, UMMI ATIAH BINTI MOHAMAD, M20181000730, FACULTY OF SCIENCE & MATHEMATICS (PLEASE INDICATE STUDENT'S NAME, MATRIC NO. AND FACULTY) hereby declare that the work entitled THE DEVELOPMENT OF A GEOMETRICAL OPTICS LEARNING MODULE (GOLeM) AND ITS USABILITY AMONG PHYSICS MATRICULATION STUDENTS is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

Signature of the student

ii. Supervisor's Declaration:

I DR THO SIEW WEI (SUPERVISOR'S NAME) hereby certifies that the work entitled THE DEVELOPMENT OF A GEOMETRICAL OPTICS LEARNING MODULE (GOLeM) AND ITS USABILITY AMONG PHYSICS MATRICULATION STUDENTS (TITLE) was prepared by the above named student, and was submitted to the Institute of Graduate Studies as a * partial/full fulfillment for the conferment of MASTER OF EDUCATION (PHYSICS) (PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

12/10/2021

Date

DR. THO SIEW WEI

Signature of the Supervisor

UPSI/IPS-3/BO 31
Pind.: 01 m/s:1/1

SULTAN IDRIS EDUCATION UNIVERSITY

INSTITUT PENGAJIAN SISWAZAH /
INSTITUTE OF GRADUATE STUDIES

BORANG PENGESAHAN PENYERAHAN TESIS/DISERTASI/LAPORAN KERTAS PROJEK
DECLARATION OF THESIS/DISSERTATION/PROJECT PAPER FORM

Tajuk / *Title*: THE DEVELOPMENT OF A GEOMETRICAL OPTICS LEARNING MODULE (GOLeM) AND ITS USABILITY AMONG PHYSICS MATRICULATION STUDENTS

No. Matrik /*Matric's No.*: M20181000730

Saya / *I* : UMMI ATIAH BINTI MOHAMAD

(Nama pelajar / *Student's Name*)

mengaku membenarkan Tesis/Disertasi/Laporan Kertas Projek (Kedoktoran/Sarjana)* ini disimpan di Universiti Pendidikan Sultan Idris (Perpustakaan Tuanku Bainun) dengan syarat-syarat kegunaan seperti berikut:-
acknowledged that Universiti Pendidikan Sultan Idris (Tuanku Bainun Library) reserves the right as follows:-

1. Tesis/Disertasi/Laporan Kertas Projek ini adalah hak milik UPSI.
   The thesis is the property of Universiti Pendidikan Sultan Idris

2. Perpustakaan Tuanku Bainun dibenarkan membuat salinan untuk tujuan rujukan dan penyelidikan.
   Tuanku Bainun Library has the right to make copies for the purpose of reference and research.

3. Perpustakaan dibenarkan membuat salinan Tesis/Disertasi ini sebagai bahan pertukaran antara Institusi Pengajian Tinggi.
   The Library has the right to make copies of the thesis for academic exchange.

4. Sila tandakan (√) bagi pilihan kategori di bawah / *Please tick (√) for category below:-*

☐	**SULIT/*CONFIDENTIAL***	Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub dalam Akta Rahsia Rasmi 1972. / *Contains confidential information under the Official Secret Act 1972*
☐	**TERHAD/*RESTRICTED***	Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan ini dijalankan. / *Contains restircted information as specified by the organization where research was done.*
☑	**TIDAK TERHAD / *OPEN ACCESS***	

(Tandatangan Pelajar/ Signature)

DR. THO SIEW WEI
Pensyarah Kanan
Jabatan Fizik
Fakulti Sains Dan Matematik
Universiti Pendidikan Sultan Idris

(Tandatangan Penyelia / *Signature of Supervisor*)
& (Nama & Cop Rasmi / *Name & Official Stamp*)

Tarikh: 12/10/2021

Catatan: Jika Tesis/Disertasi ini **SULIT** @ **TERHAD**, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan ini perlu dikelaskan sebagai **SULIT** dan **TERHAD**.

Notes: If the thesis is CONFIDENTAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deep gratitude to Allah, the most powerful that had eased the journey of this research. Next, an enormous appreciation goes to my research supervisor Dr. Tho Siew Wei, senior lecturer in the Sultan Idris Education University, the one who had given me invaluable guidance, help and support from the start and it was an honour to work with him in completing this research. Without him, my work might be not well pointed.

To my supportive and loving husband, Ahmad Mustaqim Abd Rahman, thank you for always supporting my dream. Your huge sacrifice and patience when I did my research work and thesis preparation are unpaid. You had ensured everything around were properly taken care of especially the children. I am also extending my heartfelt thanks to my so-called supportive sons Qayyim Afif and Abdullah Qawiy, my mother, Wan Rokiah Wan Muda and my siblings for their acceptance, understanding and prayers.

Finally, my gratitude goes to those who have directly or indirectly supported me throughout this illustrious journey including my lovely colleagues and my head of department as well as the director of Perak Matriculation College. Thank you very much.

ABSTRACT

This study aimed to develop and determine the usability of Geometrical Optics Learning Module (GOLeM) towards Physics Matriculation students. The GOLeM was developed using ADDIE (Analyze, Design, Develop, Implement, Evaluate) model and this module had been validated by seven experts. This research used a questionnaire to evaluate the usability of the developed module. The research sample consisted of 186 students that was selected through cluster random sampling from an accessible population of 359 Physics Module II students in Perak Matriculation College. The research instrument was usability questionnaire that was used to measure the students' perceptions towards the usability of the module. The questionnaire was adapted based on the Technology Acceptance Model (TAM). The data were analysed using descriptive and inferential statistics including frequency, mean, standard deviation and independent t-test. The average mean score for five constructs (M=4.46; S.D.=0.39) depicted that GOLeM was usable. Additionally, the average percentage of agreement for all constructs was high (96.6%). The t-test analysis showed significant differences between male and female students in the constructs of perceived usefulness (PU) ($t(184) = 2.48$, $p=0.014$), behavioral intention (BI) ($t(184) = 3.343$, $p=0.001$) and self-efficacy (SE) ($t(184) = 3.061$, $p=0.002$). In conclusion, the main finding of the study showed that GOLeM is valid and has higher level of usability among Physics Matriculation students especially for the topic of Geometrical Optics. The research implication affects the field of module development at Matriculation level, encourage Matriculation lecturers to be more proactive in producing similar modules for all subjects. The use of smartphone technology and mobile applications in the other module may also be improved and diversified.

PEMBANGUNAN MODUL PEMBELAJARAN OPTIK GEOMETRI (GOLeM) DAN KEBOLEHGUNAANNYA DALAM KALANGAN PELAJAR FIZIK MATRIKULASI

ABSTRAK

Kajian ini bertujuan untuk membangunkan dan menentukan kebolehgunaan *Geometrical Optics Learning Module* (GOLeM) terhadap pelajar Fizik Matrikulasi. GOLeM dibangunkan menggunakan model ADDIE (*Analyze, Design, Develop, Implement, Evaluate)* dan telah disahkan oleh tujuh orang pakar. Kajian ini menggunakan instrumen soal selidik untuk menilai kebolehgunaan modul yang dibangunkan. Sampel kajian terdiri daripada 186 pelajar yang dipilih melalui pensampelan rawak berkelompok dari populasi yang boleh diakses iaitu 359 pelajar Modul II Fizik di Kolej Matrikulasi Perak. Instrumen kajian adalah soal selidik kebolehgunaan yang digunakan untuk menilai persepsi pelajar terhadap kebolehgunaan modul. Soal selidik ini diadaptasi daripada *Technology Acceptance Model* (TAM). Data dianalisis menggunakan statistik deskriptif dan inferensi termasuk frekuensi, min, sisihan piawai, dan ujian t tidak bersandar. Skor min purata untuk lima konstruk ($M = 4.46$; $SP = 0.39$) menggambarkan bahawa GOLeM boleh digunakan. Selain itu, purata peratusan persetujuan untuk semua konstruk adalah tinggi (96.6%). Analisis ujian-t menunjukkan perbezaan yang signifikan antara lelaki dan wanita dalam konstruk andaian kegunaan (PU) ($t(184) = 2.48$, $p = 0.014$), niat tingkah laku (BI) ($t(184) = 3.343$, $p = 0.001$) dan efikasi kendiri (SE) ($t(184) = 3.061$, $p = 0.002$). Kesimpulannya, dapatan utama kajian menunjukkan bahawa GOLeM adalah sah dan mempunyai tahap kebolehgunaan yang tinggi di kalangan pelajar Fizik Matrikulasi untuk topik Optik Geometri. Implikasi kajian memberi kesan kepada bidang pembangunan modul di peringkat matrikulasi, mendorong para pensyarah matrikulasi untuk menjadi lebih proaktif dalam menghasilkan modul yang sama untuk semua mata pelajaran. Penggunaan teknologi telefon pintar dan aplikasi mudah alih dalam modul yang lain juga dapat ditingkatkan dan dipelbagaikan.

CONTENTS

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AT	Attitude
BI	Behavioural Intention
CDD	Curriculum Development Division
CS	Curriculum Specification
CVI	Content Validity Index
EPRD	Educational Planning and Policy Research Division
GO	Geometrical Optics
GOLeM	Geometrical Optics Learning Module
ICT	Information and Communication Technology
IPO	Input-Process-Output
KMPK	Perak Matriculation College – *Kolej Matrikulasi Perak*
MOE	Ministry of Education
MQA	Malaysian Qualification Accreditation
NRC	National Research Council
PE	Perceived Ease of Use
PPPM	*Pelan Pembangunan Pendidikan Malaysia*
PSPM	*Peperiksaan Semester Program Matrikulasi*
PU	Perceived Usefulness
QR	Quick Response
SDS	*Sistem Dua Semester*
SE	Self-efficacy
SES	*Sistem Empat Semester*

SME	Subject Matter Experts
SPM	*Sijil Pelajaran Malaysia*
SPSS	Statistical Package for the Social Science
STEM	Science, Technology, Engineering & Mathematics
T&L	Teaching & Learning
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
VIQ	Validity Open-ended Question for Interview Questions
VQM	Validity Questionnaire for Module
VQUQ	Validity Questionnaire for Usability Questionnaire

APPENDIX LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

Evolvement of economy and success of a country is often associated with the knowledge and skills possessed by the people. Both knowledge and skills can be developed through the process of teaching and learning (T&L) that are well versed in education sector. Education is constantly evolving and changing according to current and future needs. This sector promises a continuous effort to produce excellent future generation in terms of physical, emotional, spiritual, intellectual and social. Likewise, the government of Malaysia provided a plan in implementing a transformation for education that is named as Malaysia Education Blueprint (*Pelan Pembangunan Pendidikan Malaysia* - PPPM) 2013-2025. PPPM works for the implementation of a holistic transformation of the national education system (Ministry of Education [MOE], 2018).

There are six students' aspirations listed by PPPM 2013-2015 knowledge; thinking skill, leadership skill, bilanguange skill, ethique and spiritual as well as national identity (MOE, 2013). All of these components are likely to have a profound effect on survival, success, and well-being of students especially in confronting the challenges of 21st century, apart from providing them to be resourceful to the country (MOE, 2018). PPPM (2013-2025) covers a range of students' levels under MOE starting from pre-schoolers up to the students in tertiary level. MOE has provided various options for post-secondary education to ensure students have a robust foundation in preparation at the tertiary level, such a Matriculation Programme, Sixth Form, Malaysian Islamic Religion Higher Certificate (*Sijil Tinggi Agama Malaysia* - STAM) and Bachelor's Degree in Teaching Programme (*Program Ijazah Sarjana Muda Perguruan* - PISMP) (MOE, 2018).

In Malaysia, the implementation of pedagogical approach in T&L is guided by the government curriculum basis. According to Alias et al (2014), curriculum is a learning experience that is provided in the form of lesson plan. For the Matriculation Programme, the T&L process is conducted based on the Curriculum Specification (CS) for all individual subjects including Physics. The learning curriculum for the Matriculation Programme is revised for at least once in three years or according to current needs (Matriculation Division, 2019). Matriculation curriculum and school curriculum are the same on the basis level. The National Physics Curriculum in Curriculum Development Division (CDD) sets its framework for physics learning. The framework aims students to be more knowledgeable and skilful in science and technology, leading to a more dynamic society and able to contribute to the country (CDD, 2012). Physics is commonly perceived as a subject that is too abstract and the students' limited imagination causes the abstract concepts are not able to be clearly clarified (Lederman & Abell, 2014). The T&L methods may affect students' learning process. Hence, step by step resolution on the abstraction levels need to be done onto the theories of particular Physics concepts in developing the learning process among students and building their understanding. This process is part of constructivism in learning which can be implemented through Science, Technology, Engineering and Mathematics (STEM) based learning (Ullman, Stuhlmueller, Goodman, & Tenenbaum, 2014).

The emphasis on STEM subjects and the idea of integrating these subjects were stimulated when the United States (US) noted the decrease in qualified workforces in STEM-associated industries (National Research Council [NRC], 2012). Following that, the US government took steps to introduce the concept of STEM learning at schools to cultivate interest towards these subjects especially Science encompassing Physics, Chemistry and Biology and to encourage youth to pursue STEM careers. This phenomenon resonates with several developing countries in the world including Malaysia. The purpose of STEM is basically to develop strong basis of science and technology incorporated through Mathematics and Science curriculum framework leading the students to be innovative, think critically, and possess the ability in problem-solving (Kennedy & Odell, 2014; Wan Husin et al., 2016). Specifically, the aim of STEM education in Malaysia is to equip students with skills that enable them to confront the challenges in science and technology. Apart from that, it intends to increase the number of STEM graduates with higher level of qualification. The CDD in MOE has also outlined the STEM-based education in the government's 2016 to 2020 education plan for enhancing of career paths and introduced the innovations of Information and Communication Technology (ICT) (CDD, 2016).

Physics course either in Matriculation Programme or university is normally dominated by male students. The higher number of male students must be contributed by certain factors and causes. In the existing literatures, it shows inconsistency of reviews in the involvement of male and female students in Science subjects in general, particularly Physics. Several reviews agreed on the gender differences in learning (Sencar & Eryılmaz, 2004; Tsai & Huang, 2018), while research found that the selection of subjects among students is irrespective of gender (Kaltakci-Gurel, 2018) as it may depends on the level masculinity and femininity of particular person. The study of gender is important to help educators to provide suitable teaching and learning instructional strategies.

1.2 Research Background

The MOE Matriculation Programme established in 1998 is a preparatory program for pre-university students before continuing their studies to the first-degree level in areas related to science, technology and professional literature at institutions of higher education either locally learning or abroad (Matriculation Division, 2019). The programme is specifically run at Matriculation colleges distributed all over the country. Overall, there are 15 Matriculation Colleges nationwide including 3 Matriculation Engineering Colleges. The Matriculation Programme under the MOE is divided into two systems that are two-semester and four-semester systems specifically known as the *Sistem Dua Semester* (SDS) and *Sistem Empat Semester* (SES) respectively. SDS offers three different streams; science, accounting, and technical (engineering), whereas SES only offers Science course. Under the science stream, both SDS and SES offer 3 modules namely Module I, II and III. Module I and Module II provide Physics as the elective subject apart from the core subjects Mathematics and Chemistry (Refer **Table 1.1**). Due to several rationales that are discussed in Chapter 3, this study was only conducted on Module II of SDS students.

Table 1.1

Science Stream Subjects for SDS and SES

Stream	Module I	Module II	Module III
Science	▪ Mathematics (Science) ▪ Chemistry ▪ Physics ▪ Biology	▪ Mathematics (Science) ▪ Chemistry ▪ Physics ▪ Computer Science	▪ Mathematics (Science) ▪ Chemistry ▪ Biology ▪ Computer Science

Physics T&L in the Matriculation Colleges is implemented though the media of lectures, tutorials and practical. The academic performance of Physics Matriculation students is evaluated through formative (60%) and summative assessments (40%). They are assessed formatively through Continuous Assessment (*Penilaian Berterusan* - PB) whereas the summative assessed through the Matriculation Programme Semester Examination (*Peperiksaan Semester Program Matrikulasi* - PSPM). Physics is among the compulsory subjects to qualify students to be accepted in engineering, technology and all other Science courses in public universities. This means that the students' process of learning and understanding of Physics in Matriculation will give impacts on their choices for university.

In Physics, optics is a major area in which its application is widely benefits life such as in the branches of optometry and health. Physics CS for Matriculation is designed in accordance with continuation of Physics at secondary level in high school. In the CS, optics is specified into two chapters which are Geometrical Optics (GO) and Physical Optics (PO). GO focuses on the phenomena of light reflection and refraction; the selected area for this study. PO on the other hand encompasses the Physics concepts of light interference and diffraction. However, in a more general form, optics is categorized into classical and modern optics. GO and PO are the branches of classical optics. Meanwhile, the modern optics is specifically explaining the quantum theory of light. The difference of the two optics categories is basically due to the contribution of additional optical instruments for quantum experiments in this modern era that does not yet exist the classical optics (Weener & Dirk-Gunnar, 2006).

GO holds its basic postulates of that light propagates in straight line and when light rays intersect, they will not affect each other. These two postulates consequently explain the reflection and refraction phenomena. In addition, it also explains how real or virtual image is formed through the intersection of the rays that can imaginarily visualized by ray diagrams (Milton, 2002). On the other hand, PO describes how light interacts with matter and proves the wave theory of light though the phenomena of interference and diffraction. A series of theories expansion of the wave theory with experimentations occurred from several physicists such as Huygens, Thomas young and Fresnel (Milton, 2002). The investigations evolved among the scientists until it came to a modern quantum optics early discovered in 1977 (Weener & Dirk-Gunnar, 2006). In this quantum theory of light, Planck showed that light is quantized. It absorbs and radiates in form of discrete bundle of energy and the idea was extended by Einstein by introducing photoelectric effect. The discrete bundle is known as photons as the quantum of light. In this line of quantum optics, photon is treated to have properties of both particle and wave (Milton, 2002; Walls & Milburn, 2007).

According to Malaysia's new secondary school curriculum called *Kurikulum Standard Sekolah Menengah* (KSSM), students start to learn GO during their first year of upper secondary level (CDD, 2018). The content is then proceeded with a more advanced syllabus in Matriculation. Generally, the very basic content of GO as for instance the laws of refraction and refraction are covered in schools. In comparison, some concepts such as sketching ray diagrams for spherical mirror and lens, and thin lens equation are somehow covered in both school and Matriculation levels. The Matriculation CS extends the syllabus by introducing a new subtopic that is lens maker's equation. In this subtopic, students learn the effect light refraction on various more types of concave and convex lens in certain media.

In our daily life, we directly or indirectly deal with light and its basic phenomena can be described by GO. Moreover, GO is a course found in most institutions of higher level nowadays. It proves that it is significant for application in real life. Due to this, it becomes a great challenge for educators to use efficient ways of teaching GO. As the physical form of light rays is abstract, it is being is a requirement for educators to provide the best learning strategy to help students learning for this topic. The different ways of how light responses upon materials in terms of its directions may leads to student's confusion on the concepts. This learning objective of GO can be achieved through various instructional strategies of T&L including the hands on practical work (Donnelly, Magnani & Robinson, 2016) and learning through theory (Kristiawan, 2015). There are various free mobile apps provided in mobiles that can be applied in this research study as a resolution using digital technology in order to enhance the imagination of optics including the phenomena of reflection and refraction (Kristiawan, 2015).

Active learning is able to enhance students process of learning as well as improving their learning performance (Brame, 2016). The use of suitable T&L instructional meterial is required for the sake of providing active learning environment. Modules are among the T&L materials that are practised nowadays by particular educators and schools. In fact, the use of modules are proven helpful for diversifying T&L techniques for various levels of education including schools (Shaheen & Khatoon, 2017), matriculation (Hashim, 2017; Cheng, 2020) and postgraduate (Norazman, Sazelli, & Firdaus, 2014; Sadiq & Zamir, 2014). This provides variation in the T&L, encourages collaborative learning and improve students' learning interest (Mohd Noah & Ahmad, 2005; Norazman et al., 2014).

STEM learning style is another approach that mediates active and collaborative learning (Havice, Havice, Waugaman, & Walker, 2018). Therefore, by employing the adaptation of eight elements of STEM practice in a module which assimilates the use of technology (Srisawasdi & Panjaburee, 2014), it is expected that the physics learning of GO will be comprehensible. Moreover, the implementation in ICT for Science in important, for instance EduwebTV, a programme that provides videos for education which initiated by the government a good example of impressive efforts to improve science learning particularly (MOE, 2012). The development of this module is also in line with the government's vision to reinforce STEM in Malaysia (Shahali, Ismail, &

Halim, 2017). Thus, this research aimed to develop Geometrical Optics Learning Module (GOLeM) for students using adaptation of eight elements of STEM practice via smartphone based on developmental research using ADDIE model. The developed module comprised smartphone-based mobile learning and hands-on practical work. A need analysis was carried out to evaluate the level of requirement for this module to be developed and the findings were elaborated in subtopic 1.3.

1.3 Research Need Analysis

As a start for the study, a need analysis was conducted in addressing the suitability of GO as the topic of investigation and the adaptation of eight elements of STEM practice in Matriculation. In order to provide the data for analysis, the researcher applied an interview method on Physics lecturers from a Matriculation College as the respondents. Interview is one of the data collection techniques that is able to gather respondents' perceptions and opinions more thoroughly and in a flexible way. This technique proposes a thorough process of seeking particular information from the respondents (Adhabi & Anozie, 2017). The implementation of interview method for the current study was intended to attain the respondents' thoughts and their feelings towards the selected topic of study and to what extent do the respondents understand and the adaptation of eight elements in STEM practice at Matriculation level.

In this research, a semi-structured interview was selected as the method of data collection for the need analysis. This type of interview outlines an interview guide that enables the interview to focus on particular issues through provided specific questions.

The interviewer prepared a set of structured interview questions, and the questions are consecutive and interrelated (Stuckey, 2013). This method allows the interviewees to respond as appropriate as possible to the questions. However, the interviewees were not given any choices of answers which hence allows them to express any desirable terms that relate to the questions (Cridland, Jones, Caputi, & Magee, 2015; Evans & Lewis, 2018). Meanwhile, the answers given by the respondents can be diverted by the researcher which consequently led to lengthy session during the semi-structured interview (Kallio, Pietilä, Johnson, & Kangasniemi, 2016). In addition to that, a face-to-face interview was conducted to acquire genuine data for the need analysis. This is because the respondents delivered their responses along with their gestures and authentic experience that had helped the researcher to do an in-depth data analysis.

In the context of this study, the questions were designed properly to have an organised data array in accordance difficulty in GO, teaching practices in classroom, and their perceptions towards the adaptation of eight elements of STEM practice. The interview questions for this research are shown in Appendix A. Meanwhile, the respondents for the interview were among Physics educators and the demographic and professional characteristics of participants are summarised in **Table 1.2**. The interviewees in this research have been working for more than 10 years in the Physics field and have experienced various workplaces.

Table 1.2

Respondents of Interview

No.	Interview Respondents	Teaching Experience in Physics
1.	Lecturer A	Matriculation (20 years)
2.	Lecturer B	Matriculation (13 years)
3.	Lecturer C	Schools & Matriculation (13 years)

In conducting the interview, all the three participants were asked for their formal consent by signing a consent form provided by the researcher (Refer to Appendix B). During this face-to-face interview, the data were collected using questions that had been prepared beforehand in English language. However, the interview session was conducted in Malay; the native language for the lecturers to secure a comfort and free conversation so that there would be a genuine response besides the attempt to avoid the language constraint between the interviewer and interviewees. Nevertheless, the responses were audio-recorded during the session for transcript preparation (Chamberlain, Duggleby, Teaster, & Estabrooks, 2020).

The analysis based on the collected data from the interview was implemented using thematic analysis. This was done by categorising the output from the interviewees through the transcript into themes and subthemes, therefore the patterns of responses and their significances to the research can be clearly seen (Evans & Lewis, 2018). Throughout the data findings, the researcher had identified two main themes for the questions that were asked. The first theme was in regard with the mastery of GO, followed by the second theme of adaptation of STEM practice among lecturers and students. **Table 1.3** visualises the themes and subthemes of the need analysis of developing GOLeM.

Table 1.3

Theme and Subthemes from Interview Data

No.	Themes	Subthemes
1.	Teaching GO	- Traditional teaching methods - Light converging and diverging processes
2.	Practices of STEM- adapted learning among students and lecturers	- Learning through inquiry - Teaching aid using ICT - Teaching and learning through adaptation of eight elements of STEM practice
3.	Gender differences on GO	- Interest & achievement during learning

For the first theme, two out of three respondents admitted that they still use traditional teaching method of 'chalk and talk' for GO. Lecturer C's response *was 'I draw the ray diagram, in order to get the characteristics of image form, and its position'.* The next subtheme was on the content of GO where 100% of the responses stated that students do not have a clear understanding on the processes of converging and diverging of light ray upon the concepts of reflection and refraction. This was due to the character of light ray itself that is unseen to our naked eyes. Lecturer B's statement on this was *'Everything is invisible, hence students are not able to show and prove the position of image and object, despite the theory was understood.'* Lecturer A on the other hand pointed out the problem in sign convention of this topic. Lecturer A's statement was *'Students also face problems for this topic, especially when drawing diagrams, using formulas and sometimes in using sign conventions.'* Moreover, all respondents believed that GO topic is important as it may affect the student's future in terms of knowledge, real life application and career. Among the responses was 'Geometrical Optics is very important because it relates to those around us, light is related to vision, so the effect of this light phenomenon is important for us to relate or apply in life.'

The second theme from the collected data was the introduction of adaptation of STEM practice as a teaching and learning method. The first subtheme was on learning through inquiry which was found as unfamiliar to these respondents. Although Lecturer A had introduced inquiry learning during the laboratory session, this approach had never been used during the tutorial session. Similarly, Lecturer B had never given any attempt for learning through inquiry on top of underestimating her students by giving a statement *'Students do not explore on their own because honestly I think our students are still unable to be allowed to explore on their own in achieving learning objectives.'* This shows a lack of trust from educators towards the students which put a doubt on educators in general whether they attempt to apply any new learning approach. Next, in terms of teaching aid using information and ICT, two of the respondents had no experience in it as they prefer the conventional learning approach. Lecturer C addressed this point by saying *'I don't use any ICT integrating during GO learning as I am more to traditional method. For this topic, I do more pen drawings with students and constructs pneumonic.'* Based on this statement, the researcher believes that the learning process might be not as interesting as integrating mobile technology such as simulations through mobile applications. Lastly, the theme was on adaptation of eight elements in STEM practice where none of the interviewees applied this learning style in their lesson. This is due to their limited knowledge on this approach which hence prohibits students in learning using the adaptation of STEM practice. Lecturer A's confession was *'I myself as a lecturer have never used the adaptation of eight elements in STEM practice according to the actual steps projected. Because I do not know.'*

The last question for the interview was on gender difference of students when learning GO. The respondents' views showed inconsistent results in which two of them thought that there is no difference between male and female students in terms of interest and achievement. From the need analysis interview elaborated above, it is clearly shown that there is a need in developing Geometrical Optics learning module that is linked to adaptation of eight elements of STEM practice in order to boost students' interest in learning GO which indirectly improves their understanding. There is also a need to investigate the gender differences or gender gap when they learn this topic using a module.

1.4 Problem Statements

In Physics, most of its concepts are not simply comprehended due to its complexity which restrains students from having a clear imagination (Rau, 2017; Saleh, 2014). The concept is perceived as abstract because of students' inability to make connection with the representation of its processes (Rau, Aleven, Rummel, & Pardos, 2014). This reason of difficulty in learning Physics is not exceptional for GO topic that is taught in higher levels of secondary schools and tertiary education including Matriculation and pre-university. The reality is that the content in GO especially the paths of light ray are unable to be seen with the naked eyes which explain why students failed to fully understand this topic. GO focuses on reflection and refraction light phenomena which involves an invisible process of multiple lines of light rays diverting the orientation upon different media. There were also several studies that investigated the concept of reflection (Magnani & Donnelly, 2015), refraction (Toyoda, Abe, & Arima, 2019) and both phenomena (Donnelly et al., 2016) proving that these concepts are not simply taught by educators. Studying GO is crucial in addition to optics has also been a trend in studies because of its relevance and compliance for researches among developing countries as it is a challenging topic to be delivered (Galili & Hazan, 2000).

A study conducted by Tural (2015) discovered that students were confused with the concept of diverging and converging light upon concave and convex lens and spherical mirror. Moreover, these concepts are related to angles at the boundary of two media of different refractive indexes. The confusion could arise due to the lack of understanding on the fundamental laws of reflection and refraction, the way they learnt this chapter during teaching and learning (T&L) process. Students are supposed to grasp these fundamental laws during their schooling years, and they are still unable to master the concepts in GO during secondary schools (Chen, Lin, & Lin, 2002; Favale & Bondani, 2013) specifically for the concept of reflection at spherical mirror (Carolin, Sahala, & Mursyid, 2016; Novianti & Sarkim, 2017) due to misconception in this topic (Kaltakci-Gurel, Eryilmaz, & McDermott, 2016). The studies on GO were also widely investigated in universities (Bendall et al., 1993; Blizak et al., 2013) and in fact the students' misconception in GO was still found in Semester 5 of degree years (Handayani, 2018). Knowing that failure to grasp the ideas in GO throughout secondary would make students to struggle with mastering other related optics topics in higher education. Hence, this problem must be resolved in all levels including post-secondary level to inculcate students' interest in learning GO (Li & Zhou, 2017).

Prior research studies in Malaysia and overseas have demonstrated that the skills of problem-solving is a serious difficulty that students encounter at the matriculation level (Hom & Talib, 2020). Students were unable to master the problem solving in physics leading to less performance and interest during learning. Moreover, problem solving that can be developed through STEM learning (Zainal et al., 2018) is also less researched at the matriculation level compared to the primary and secondary level (Bakar, Salim, Ayub, & Gopal, 2021). On top of that, Hung, Abdullah, and Bunyamin (2013) reported that the level of post-secondary students for application of physics concepts in solving STEM-based problems is low. This is due to the lack of practice in applying physics concepts to STEM-related problems. As a result, students struggle to grasp abstract concepts and are unable to use physics principles to solve STEM-related problems. This situation is worrying as the Matriculation Programme was supposed to be a platform to develop the potential among students to qualify them in continuing studies to a higher level in STEM and professional fields (Matriculation Division, 2019).

The paucity of literature for GO in Matriculation Programme indicates that there are still few GO studies undertaken at the Matriculation level or in any programme equivalent to that. In the Matriculation level, failure to score in GO problem solving in either the continuous assessment (PB) or the final examination (PSPM) resulted in a significant loss of total marks. This is due to the fact that GO questions award among the highest score of all topics (15 marks). As a result, GO has an impact on students' achievement in Physics due to the ineffective learning process that students are subjected to. Furthermore, it may have an impact on students' eligibility to enrol in universities, as many university courses, including medical courses, need Physics as a prerequisite (Redish et al., 2014). Through Physics, the outcome of learning this subject is thought to boost efficiency in students' work at the degree level (Shurygin & Krasnova, 2016). Prior to the 2019/2020 Matriculation session, students are given the opportunity to choose which topics they wanted to respond for Physics Semester II final examinations. According to a Matriculation examination report, the students were unlikely to select the GO topic to answer. Instead, they prefer to pick on other physics topics. Moreover, according to the report, students who picked GO questions were similarly unable to explain the idea of reflection. Another evaluation found that the students are unable to recognise the correct optics formula in solving particular questions. On top of that, the results from the need analysis showed that the limited learning process that lecturers have provided to their students.

Additionally, students find it difficult to grasp the abstraction in optics if they fail to link the conceptual knowledge to real-life application (Camarao & Nava, 2017; Hochberg, Gröber, Kuhn, & Müller, 2014). This problem is indirectly related to T&L methodology that is supposed to embrace real-life application to the concept learnt. It is evident that students in higher institutional level are lacking in exposure to real-life experience for their learning which affects their training and career (Bishop, 2019). This deficiency causes the limitation in expanding the knowledge leading to poor understanding of particular Physics concepts. Kolb (2014) stated that learning takes place when the learners are directly in contact with what is real, and learning is productive when the theory and practice are combined. The practice is basically based on the students' experience when they are in relationship with time, situation and places which basically explain the meaning of contextual learning (Falk & Dierking, 2018).

Limited STEM learning among students is due to a lack of awareness among students and a belief that STEM is difficult (MOE, 2013).

Although the modules are extensively utilised in schools and at the higher level of education, few studies on the modules are implemented at the preparatory program level (Dhamija, Kanchan, & Education, 2014), such as the Matriculation Programme. The existing modules are less attractive in addition to the limited use of technology (Murni, Helma, & Mirna, 2019). Lectures and tutorials at Matriculation are still primarily concentrated on the lecturers (Lok & Yau, 2020). Hence, appropriate learning support materials are needed for Matriculation physics learning as students at the preparatory programme level such as the Matriculation need to be exposed to the concept of student-centered learning. Traditional teacher-centred learning methodology that has been practised among educators was proven as less effective to produce students with higher level of thinking, interaction and creativity (Radzali, Mohd-Yusof, & Phang, 2018) and results in passive students as the learning input only comes from the educators and there is no student's engagement towards the learning content (Ismail, Sawang, & Zolin, 2018). This one-way teaching style focuses more on teacher's action in delivering the content and knowledge restricting fully-optimised learning by the students as they are unable to fully experience the learning themselves.

In comparison, student-centred learning concentrates on learners and the way they understand a particular content as well as working with peers without disregarding the teacher's role as the main reference during T&L session, indirectly constructing the knowledge on their own through activities in classroom mediated by ICT (Ismail et al., 2018) and experiments using scientific materials (Kasim & Ahmad, 2018). Thus, teachers' explanation in conventional teaching and learning methodology may be replaced at some parts in T&L with students' centralised learning through hands-on experience which will be able to develop students' problem-solving and scientific skills. Additionally, student-centred learning has been a common practice recently (Baeten, Dochy, Struyven, Parmentier, & Vanderbruggen, 2016; Du Plessis, 2016), thus it convinces the researcher to apply this style of learning into GOLeM.

Based on the problems stated above, to encourage learning via real-world exposure and self-centred learning, a learning module with adaptation of eight elements of STEM practice is considered as suitable. This learning promotes a relation to daily life activities, self-centred and inquiry learning using technology in designing solutions. This is significant as students who have been exposed to STEM learning will be innovative, able to invent and solve problems, which are in line with those skills needed in 21st century (Wan Husin et al., 2016). This style of learning basically promotes systematic learning of guided steps and suitable to be organised in a module, resulting in more interesting and comprehensible learning especially with the integration of smartphone-based mobile learning technology. Taking the opportunity of various free mobile technology that are available nowadays, it can be applied in learning to solve the problem and enhances the understanding through visualisation of light rays including the phenomena of reflection and refraction. In fact, blended learning is used in this research since the learning process incorporates both face-to-face learning and online learning interaction (Köse, 2010).

As reported in the results of need analysis, there are inconsistency among the respondents about their opinion on students' gender differences in learning GO.

Henderson, Stewart, Stewart, Michaluk, and Traxler (2017) in his study also stated that the gender gap is less constant in many research. Despite global efforts to close the gender gap in Science, it still remains (Tsai & Huang, 2018) notably in Physics and it requires more investigation. Thus, the researcher decided to explore on gender differences in implementing in this GO module. Several researchers found that there is a gender gap towards physics learning in which female often demonstrate a lower performance rather than males (Sencar & Eryılmaz, 2004; Tsai & Huang, 2018). This is according to the factors of first, the different brain structure between males and females and second, the social and culture both genders had experienced which depends on the way they were upbrought (Kaltakci-Gurel, 2018).

However, studies from (Muis & Gierus, 2014) in contrast has a different opinion that the type of knowledge in Physics determines the males' and females' learning perception and performance. One type of knowledge is focusing on the procedural aspects of the constructs and the other focusing on the conceptual aspects of the constructs. On the other hand, (Kaltakci-Gurel, 2018) stated that gender differences are merely determined by the content and context of certain topics. Nonetheless, research investigations have shown that there are just a few fields such as electronics and electricity, where females and men' interests differ significantly, conversely, no substantial gender differences can be detected in a large variety of different factual interests (Krapp & Prenzel, 2011). Both sexes found topics such as space, the solar system, and light to be equally fascinating, (Lavonen, Byman, Juuti, Meisalo, & Uitto, 2005). As a result, there is need in studying the use of GOLeM towards gender which then will attain the findings on the male and female students' acceptances to learning module of GO with STEM and technology. This study of Geometrical Optics module development is hoped to obtain a good and similar acceptance for both genders.

1.5 Research Objectives

1. To develop Geometrical Optics Learning Module (GOLeM) for Physics Matriculation students.
2. To determine the usability of GOLeM among Physics Matriculation students.
3. To examine gender differences in the perceived ease of use (PE), perceived usefulness (PU), attitude (AT), behavioural intention (BI), and self-efficacy (SE) towards GOLeM.

1.6 Research Questions

1. Is the newly developed Geometrical Optics Learning Module (GOLeM) have a good validity?
2. What is the usability level of GOLeM among Physics Matriculation students?
3. What are the gender differences in the perceived ease of use (PE), perceived usefulness (PU), attitude (AT), behavioural intention (BI), and self-efficacy (SE) towards GOLeM?

1.7 Hypothesis

H_{01} There are no significant gender differences in the perceived ease of use (PE), perceived usefulness (PU), attitude (AT), behavioural intention (BI), and self-efficacy (SE) towards GOLeM.

1.8 Conceptual Framework

The conceptual framework of a research is a design that shows the organization of ideas of the relationship between the variables of research. It synthesises the concepts and theories in research and every conceptual framework is specific for one research study

(Imenda, 2014; Maxwell, 2013). It acts as a guide for researchers to organise all related theories of the research and systematically prepare for the implementation. In this study, the developed GOLeM is classified as the independent variable while the usability of this module and gender differences for the constructs are the dependent variables. The module development was designed appropriately in order to produce a suitable module for students' utilisation.

The related variables are illustrated in a conceptual framework as shown in **Figure 1.1** which also depicts a combination of underlying theories and model in this research study. The conceptual framework in this study focuses on the phases of development and evaluation. The Technology Acceptance Model (TAM) and ADDIE model had been chosen to be the instructional design models of this study and the underlying theory that had been applied in this research were the theory of constructivism blended learning theory.

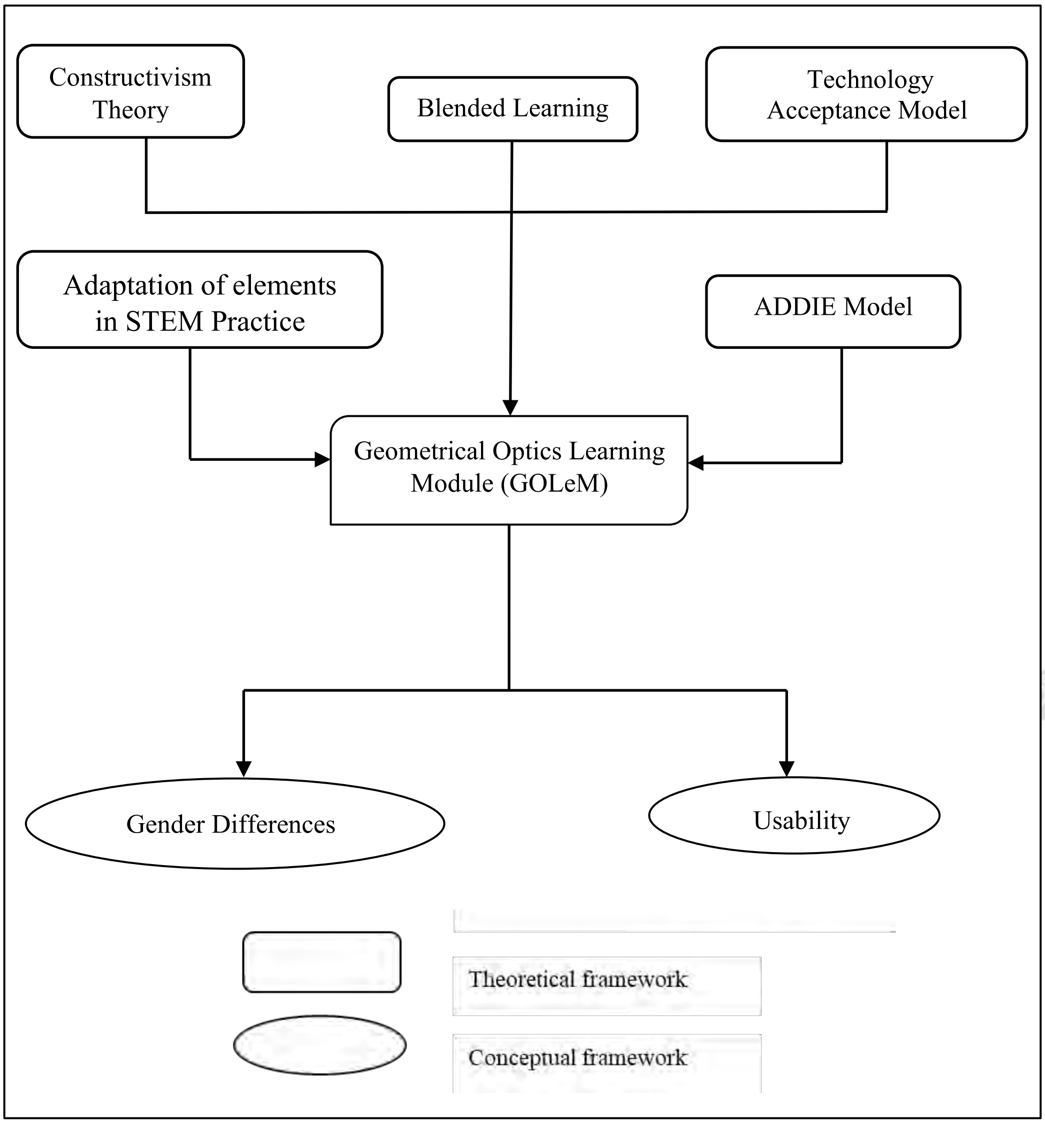

Figure 1.1. Research Conceptual Framework

Learning theory allows reliable predictions to be made about the effectiveness of chosen T&L strategies by providing information about the relationship between learning strategiy, content and students (Ertmer & Newby, 2013). The development of GOLeM was based on developmental research and ADDIE model. Module development involved the process of setting up the objectives, suitable activities and selecting the suitable media. In order to construct a practical learning module, there were many elements that had to be considered, including the theories of learning, T&L methods and how the module was going to be evaluated. Apart from that, this study also ensured that the content of the module meets Malaysian Matriculation Physics CS. In this phase, a literature review was conducted on the available learning theories that have been effectively applied by other researchers and the ones that are able to support the constructs in this study.

The theory of constructivism encompasses students' existing knowledge, learning as the outcome of student's own effort, learning that occurs when student connect the original idea with a new idea to restructure their thoughts and the roles of students collaborating, sharing ideas and experiences and making reflections (Rahim, 2017). In the context of teaching and learning, this Piaget's theory has also transformed the traditional teaching scenario in Malaysia that is from teacher-centered T&L into self-centered learning (Murad & Abdullah, 2016). Psychologist Bruner (1966) supported Piaget's theory of constructivist where both psychologists believe that an active learner builds knowledge through experiences. All learning activities need to consider students' abilities as according to El Kah and Lakhouaja (2018), to master the knowledge, new capabilities must be built based on the existing ability of the students.

Blended learning was selected as the instructional strategy to run this module. This strategy implements both face-to-face and non-face-to-face learning, or in other word, blended learning is a concept of combining conventional and online learning (Amin, 2017; Graham, 2006). Mobile learning was the subset of blended learning in this research. Mobile learning theory involves free mobile application for learning purpose. Petrova and Li (2009) proposed that the context of this theory include mobile devices, pedagogical perspectives and user interface. There have been positive impacts due to the integration of mobile learning which are normally in form interactive content in T&L that eventually marks students' increment in learning performance and behavior (Briz-Ponce, Pereira, Carvalho, Juanes-Méndez, & García-Peñalvo, 2017).

The final phase in this research was the evaluation towards the module. This was executed through a test on the usability of the developed module through a questionnaire that consisted of 22 questions adapted from Technology Acceptance Model (TAM). TAM constructs were applied for the evaluation of the usability due to the characteristics of selected learning theory and learning strategy of this module. Apart from that, gender differences analyses were performed on the five TAM constructs.

1.9 Significance of Study

Education is an area that educates people to fulfill positive characteristics in the society as the end result. The findings are generally expected to enhance the particularly in terms of T&L methods to equip students with 21st century skills. Enormous effort to improve the quality of education will have an impact to all parties, with regard to the country specifically the MOE Malaysia, educators and students.

Preparing students with 21st century skills such as thinking skill is in line with the government education framework known as Malaysia Education Development Plan

(PPPM) where one of the cores aims to improve the quality of teaching and learning. Applying the adaptation of eight elements in STEM practice in lesson favours in achieving the aim. It is hoped that this module can help the CDD and MOE in designing programs for schools and Matriculation Colleges to achieve the goals in PPPM (2013-2025). Apart from that, this research provides the adaptation of eight elements in STEM practice module with eight steps of learning process that requires the user to interact with technology specifically ICT. It is in a way supporting one of the action plans in PPPM that is to leverage ICT to improve the learning quality in Malaysia and to ensure that all Malaysian youth are equipped with digital skills and competencies required for the workforce future by the year of 2020.

Schools are capable of producing future society of great mind and skills parallel with the demands of job market. It reasons the characterization of adult workers that need to be trained from the beginning of education. With regard to this, Physics education requires great commitment from educators. Therefore, the adaptation of eight elements in STEM practice will guide teachers to clearly plan the proper teaching strategy and this module will help them with initial ideas on the alternative T&L method. It is anticipated that the results of this study will contribute to the adaptation of eight elements in STEM practice for teachers either to use or to develop their own module version. It will indirectly encourage teachers to use the adaptation of eight elements of STEM practice as their instructional strategy in classroom as many teachers are interested in STEM but have a limited knowledge on its application. As such, the development of this module is expected to help teachers overcoming the constraints. Additionally, this module is expected to guide any teachers to build their own STEM-elements-adapted module.

The development of this module provides inputs for teachers as well as students in improving the interest and achievement in Physics education. The learning on the concepts of reflection and refraction in GO is expected to be perceived better through the use of GOLeM that also encompasses an inquiry approach, the use of technology and applications in real life. Accordingly, this will enhance students' ability to solve real-life problems and produce the kind of students that have higher level of thinking skills and are able to compete globally. Therefore, the findings of this study can be a guidance and are very useful to Physics Matriculation and pre-university students in particular. The adaptation of eight elements in STEM practice also allows the inculcation of science interest among students which is significant in fulfilling the government’s aspiration to encourage STEM takers in the future.

This study is important for all public and private universities as STEM is also being outlined up to this tertiary level in education. Using the module, other researchers will discover how such learning modules can be implemented systematically by having a systematic approach. Higher institutions will be able to produce skillful graduates who have the potential to work in any fields which in the end contributes to the economy of the country. On top of that, other researchers have the opportunity to explore this adaptation of eight elements in STEM practice in other area of expertise towards contributing to the country and globally.

1.10 Limitation of Study

Nevertheless, there are some specific limitations in this study. GOLeM was developed based on the Matriculation CS of GO, thus the research participants were limited to only Physics Matriculation students of Module II. Considering the requirement of Physics as prior knowledge, students who do not take Physics subject were eliminated from the research in the first screening. Therefore, the finding is only applicable in the location of this research and can only be generalised to samples from other Matriculations under similar circumstances.

This research involved student-centred learning facilitated by the teacher in practical work. The present research only tested the usability of the module towards the students as respondents. GOLeM also applied ADDIE model as an instructional design model due to its systematic features and researchers were able conduct step-by-step process to ensure the development of the module and a well-structured evaluation (Kristanto, Mustaji, Mariono, Sulistiowati, & Nuryati, 2018). The information obtained through this research study cannot be generalised to other students as the research is specific to particular context and is not intended to create general conclusions.

This research was conducted in the form of survey research. The investigation was limited to user's acceptance towards the module. Students' achievement in GO was not examined and this was also due to the time constraint. Therefore, the findings were unable to conclude whether GOLeM is able to improve student's achievement in learning of GO in Physics.

1.11 Operational Definition

The following are the operational definitions used in this study.

Validity of Module

Module has to be validated to ensure that it is able to help students to achieve the stated learning objectives (Mohd Noah & Ahmad, 2005). According to Konting (2010), module validity means to what extent the module may collect data that encompass the contents of area to be studied. A module with high validity measures all the content of the area of study effectively. In the context of study, the validity refers to an evaluation towards the quality of the module contents. The module face validity was also conducted in this validation process. Both validation was conducted by seven appointed experts from the area of Physics and ICT including three Physics Subject Matter Experts (SME). The validation process was mediated by an instrument called Validity Questionnaire for Module (VQM), distributed to all experts.

Usability towards Physics Matriculation Students

Usability is defined as the degree to which a product may be utilised by certain users to achieve specified goals in terms of efficiency and satisfaction in specific application context (International Organisation for Standardisation (ISO) 9241-11 [ISO], 1994). In the context of this study, the newly developed module GOLeM is the product that need to be evaluated. The users for this module were the SDS Physics Matriculation students. The efficiency is related to output of the amount of time allocated and the number of steps to implement the module (Jeng, 2005), whereas, the satisfaction is measured in terms of students' perception of the product.

In the context of study, satisfaction was the only investigated item as the focus of study was on the process of learning among students, not the outcomes. The satisfaction covers the spans of perceived ease of use (PE), perceived usefulness (PU), attitude (AT), behavioural intention (BI) and the self-efficacy (SE) towards applying GOLeM. This means that students' perceptions towards GOLeM represents the measurement of usability of the module. The evaluation of the usability of GOLeM was measured by a survey method using a questionnaire that consists of 19 items of with Likert scale distributed under the constructs PE, PU, AT, BI and SE. All the items and constructs were adapted from TAM model.

Perceived Ease of Use (PE)

In Dumpit and Fernandez (2017), the definition of PE is given as 'the degree to which a person believes that using a particular system would be free of effort' (Davis, 1989, p. 320). This means that GOLeM has high degree of PE if students show positive acceptance on this integrated-technology module. This means that students have confidence that GOLeM is easy to use, free hassle in application, it does not require hard work and suitable for students' interest in learning.

Perceived Usefulness (PU)

Davis (1986) also suggested his thought on the meaning of PU in TAM which is 'the degree to which a person believes that using a particular system would enhance his or her job performance' (p. 320). The usefulness explains the ability of the technology in the module in enhancing their learning (Park, Nam, & Cha, 2012). This perception of usefulness of GOLeM determines students' enhancement in performance during learning and it is also contributing to a process for decision-making whether to use the module or not in the future.

Attitude (AT)

Attitude is represented by the positive or negative response by the users upon using the related technology (Teo et al., 2008). AT refers to the user's attitude towards the use of GOLeM either to accept or to reject. AT also marks the student's positive or negative response towards the module. AT has a strong influence on BI towards the technology use.

Behavioural intention (BI)

Behavioural Intention (BI) figures out the intention of the user's behaviour to use the module, explaining the tendency of behaviour to remain using the GOLeM. The acceptance of technology can be evaluated much on this variable. High magnitude of BI means student uses the GOLeM positively and intentionally apart from being motivated to apply the module in the future. Positive behaviour may also lead to a desire of the user to invite other users to follow the same interest.

Self-efficacy (SE)

Self-efficacy (SE) describes the 'beliefs in their capabilities to produce given attainments' (Bandura, 2006a, p. 307). Student's self-efficacy is the main factor that contributes towards student's behaviour in using the module. Those with great SE optimally prepare themselves for using GOLeM with anything they are capable of in terms efforts. The students' previous background in education field and their characteristics are crucial in influencing their self-efficacy towards acceptance of this module which then leads to a good usability of the module.

1.12 Summary

This study aimed to identify the needs of GOLeM development, develop the module and evaluate its usability towards Physics Matriculation students. The selected topic for the study was GO which was determined based on the findings from need analysis. The development of GOLeM was based on ADDIE model. TAM, ADDIE and the underlying theories that have been applied in this research were the theory of constructivism and mobile learning theory. The newly developed GOLeM was the independent variable of this study while the usability of this module and gender differences for the constructs were the dependent variables. For module evaluation, GOLeM was further tested for its usability through a survey-based study using TAM-adapted questionnaire. In short, this module is expected to be a remarkable guide for T&L as its implementation could encourage students and educators to apply the adaptation of eight elements of STEM practice and mobile technology during learning.