THE EFFECT OF A TECHNOLOGY-ENHANCED LEARNING (TEL) MODULE ON THE ACHIEVEMENT OF FORM FOUR STUDENTS IN THE TOPIC OF WAVES AND SOUND

NORFAZILAH BINTI MOHAMAD YUSUF

SULTAN IDRIS EDUCATION UNIVERSITY
2020

THE EFFECT OF A TECHNOLOGY-ENHANCED LEARNING (TEL) MODULE ON THE ACHIEVEMENT OF FORM FOUR STUDENTS IN THE TOPIC OF WAVES AND SOUND

NORFAZILAH BINTI MOHAMAD YUSUF

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

2020

UPSI/ IPS-3/BO32
Pind : 00 m/s: 1/1

UNIVERSITI PENDIDIKAN SULTAN IDRIS
SULTAN IDRIS EDUCATION UNIVERSITY

Please tick (√)	
Project Paper	
Master by Research	
Master by Mixed Mode	√
PhD	

INSTITUTE OF GRADUATE STUDIES
DECLARATION OF ORIGINAL WORK

This declaration is made on the ……..day of……..20……..

i. Student's Declaration:

I, NORFAZILAH BINTI MOHAMAD YUSUF (M20172001371) FACULTY OF SCIENCE AND MATHEMATICS hereby declare that the work entitled EFFECT OF A TECHNOLOGY-ENHANCED LEARNING (TEL) MODULE ON FORM FOUR STUDENTS IN THE TOPIC OF WAVES AND SOUND 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, NURULHUDA ABD RAHMAN hereby certifies that the work entitled EFFECT OF A TECHNOLOGY-ENHANCED LEARNING (TEL) MODULE ON FORM FOUR STUDENTS IN THE TOPIC OF WAVES AND SOUND 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), and the aforementioned work, to the best of my knowledge, is the said student's work.

_____ _____

Date Signature of the Supervisor

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 EFFECT OF A TECHNOLOGY-ENHANCED LEARNING (TEL) MODULE ON FORM FOUR STUDENTS IN THE TOPIC OF WAVES AND SOUND

No. Matrik /*Matric No.*: M20172001371
Saya / *I* : NORFAZILAH BINTI MOHAMAD YUSUF
(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 (√) from the categories 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 restricted information as specified by the organization where research was done*
☐	**TIDAK TERHAD / *OPEN ACCESS***	

_____ _____

(Tandatangan Pelajar/ Signature)
Tarikh:_____

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

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~~/Dissertation is CONFIDENTAL or RESTRICTED, please attach with the letter from the related authority/organization mentioning the period of confidentiality and reasons for the said confidentiality or restriction.

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

Alhamdulillah. All praises to Allah SWT who has given me great health and with His permission, I have completed this dissertation successfully.

First and foremost, I would like to extend my gratitude and appreciation to my supervisor, Assoc. Prof. Dr. Nurulhuda Abd Rahman who has given me ample guidance and support while allowing me to work on my way.

Deepest gratitude to Prof. Emeritus Dr. Rosly Jaafar who has introduced the Technology-Enhanced Learning tools such as Tracker and Visual Analyzer, as well as the smartphone applications which I have included in this TEL module. My heartfelt thanks to the experts; Assoc. Prof. Dr. Shahrul Kadri Ayop, Dr. Razak Abdul Samad Yahya and Dr. Nurul Syafiqah Yap Abdullah who invested their valuable time validating TEL modules and other instruments. Their guidance, insightful remarks, thoughts and suggestions have made the TEL module a better one.

Not forgetting the Scholarships and Financing Division, Ministry of Education Malaysia who has sponsored my studies.

I would also like to take this opportunity to thank my parents, Amnah Yang Ahmad and Mohamad Yusuf Aman who deserve special mention for their inseparable support and prayers. Words fail to express my gratitude to my husband, Khairul Anuar Ibrahim whose dedication, love and encouragement has taken the load off my shoulder. To my childrens; Hazeeq, Imran, Irsyad and Aisyah; believe in everything you do. Find your own path and leave a trail. You are the future and my prayers will always be with you.

To Amirah, Alyanie, Syahirah and Liyana; thank you for being part of this wonderful journey.

Finally, I would like to thank everybody who was important to the successful realisation of this dissertation which I could not mention personally one by one. You know who you are and may ALLAH reward you in this life and the next.

Thank You.

THE EFFECT OF A TECHNOLOGY-ENHANCED LEARNING (TEL) MODULE ON THE ACHIEVEMENT OF FORM FOUR STUDENTS IN THE TOPIC OF WAVES AND SOUND

ABSTRACT

The purpose of this study was to determine the effect of a technology-enhanced learning (TEL) module on the achievement of form four students in the topic of waves and sound. Constructivism was used as an underpinning theory in the development of the contents of TEL module. In terms of module development, the Sidek's model was used that has nine steps to produce a completed draft module. True-experimental design was used to determine the effect of the module. Instrument comprised a pre and post-test. The validity of the module and the instrument was verified by three experts in the field. The instrument has a relatively high reliability based on Cronbach alpha coefficient which was α = 0.81. A sample of 60 form four physics students were selected and assigned randomly into a control group (n=30) and an experimental group (n=30). The treatment for the experimental group was conducted for four weeks. In the pilot study, the experts agreed that the *TEL* module has had a high content validity with 90% agreement among the three experts. The result of the independent sample t-test [t (58) = -5.53, p < 0.05] showed that the achievement of the students in the experimental group (M = 70.33, SD = 10.31) was significantly higher than the students in the control group (M = 55.53, SD = 10.42). In conclusion, the main finding showed that the TEL module was effective in enhancing the students' achievement in the waves and sound topic. This study implicates that the TEL module could be used by physics teachers in other secondary schools in Malaysia.

KESAN PEMBANGUNAN MODUL PEMBELAJARAN DIPERKAYAKAN TEKNOLOGI (*TEL*) DAN KEBERKESANANNYA TERHADAP PENCAPAIAN PELAJAR DALAM TOPIK GELOMBANG DAN BUNYI

ABSTRAK

Tujuan kajian ini adalah untuk mengetahui kesan modul pembelajaran diperkayakan teknologi (*TEL*) terhadap pencapaian pelajar tingkatan empat dalam topik gelombang dan bunyi. Konstruktivisme digunakan sebagai teori pendukung dalam pembinaan kandungan modul *TEL*. Dari segi pembinaan modul, model Sidek yang mempunyai sembilan langkah digunakan untuk menghasilkan draf modul. Rekabentuk eksperimen benar digunakan untuk menentukan kesan modul. Instrumen terdiri daripada ujian pra dan pasca. Kesahan modul dan instrumen tersebut disahkan oleh tiga orang pakar dalam bidang ini. Instrumen mempunyai kebolehpercayaan yang agak tinggi berdasarkan pekali alfa Cronbach, α = 0.81. Sampel kajian ialah pelajar fizik tingkatan empat yang dipilih secara rawak ke dalam kumpulan (n = 30) dan kumpulan eksperimen (n = 30). Rawatan untuk kumpulan eksperimen dijalankan selama empat minggu. Dalam kajian rintis, pakar-pakar bersetuju bahawa modul TEL mempunyai kesahan kandungan yang tinggi dengan persetujuan 90% di antara ketiga-tiga pakar tersebut. Hasil ujian-t sampel bebas [t (58) = -5.53, $p < 0.05$] menunjukkan bahawa pencapaian pelajar dalam kumpulan eksperimen (M = 70.33, SD = 10.31) lebih tinggi daripada pelajar dalam kumpulan kawalan (M = 55.53, SD = 10.42). Kesimpulannya, dapatan utama menunjukkan bahawa modul TEL berkesan dalam meningkatkan pencapaian pelajar dalam topik gelombang dan bunyi. Implikasi kajian ini menunjukkan bahawa modul TEL dapat digunakan oleh guru fizik di sekolah menengah yang lain di Malaysia.

CONTENTS

		Page
DECLARATION OF ORIGINAL WORK		ii
DECLARATION OF DISSERTATION		iii
ACKNOWLEDGEMENT		iv
ABSTRACT		v
ABSTRAK		vi
CONTENT		vii
LIST OF TABLES		xii
LIST OF FIGURES		xiv
LIST OF GRAPHS		xvi
LIST OF ABBREVIATIONS		xvii
LIST OF ATTACHMENTS		xviii
CHAPTER 1: INTRODUCTION		1
1.1	Research Background	1
1.2	Problem Statement	5
1.3	Objectives	9
1.4	Research Questions	9
1.5	Hypothesis	10
1.6	Significance of Research	10
1.7	Research Scope	12

1.8 Definition of Terms 13

1.8.1 Technology-Enhanced Learning 13

1.8.2 Visual Analyzer (VA) 14

1.8.3 Sound Waves 15

1.9 Operational Definition 15

1.9.1 Achievement 16

1.9.2 Validity of TEL module 17

1.9.3 Reliability of the TEL module 18

1.10 Conceptual Framework 19

1.11 Summary 21

CHAPTER 2: LITERATURE REVIEW 22

2.1 Introduction 22

2.2 Creating 21st Century Learning Environment and Technology Competency 24

2.3 Learning Sound Waves and its Challenge 26

2.4 Using Smartphones as a Measurement Device 28

2.5 Effect of implement TEL on students Learning Experience 31

2.6 Learning Theories for Module Development: Bridging Behaviourism and Constructivism 33

2.7 Summary 38

CHAPTER 3: METHODOLOGY 39

3.1 Introduction 39

3.2 Research Design 40

3.3	Research Procedure		44
3.4	Research Variables		46
	3.4.1	Independent Variable	46
	3.4.2	Dependent Variable	47
3.5	Population and Sampling		47
3.6	Research Instrument		49
	3.6.1	Content Validity Form for the TEL Module	52
	3.6.2	Face Validity Form for the TEL module	55
	3.6.3	Achievement Test on the topic of Sound Waves Interference	56
	3.6.4	Content Validity Form for the Achievement Test	57
	3.6.5	Face Validity Form for Achievement Test	57
	3.6.6	Validity Form for the Questionnaire on the Reliability of the TEL module	58
	3.6.7	Questionnaire on the Reliability of the TEL module	58
3.7	Pilot Test		60
3.8	Field Research		61
3.9	Data Analysis		65
	3.9.1	Data Preparation	65
		3.9.1.1 The Normal Distribution Test	66
		3.9.1.2 Analysis of Equality between Groups	70
	3.9.2	Hypothesis Testing	71
3.10	Summary		73

CHAPTER 4: MODULE DEVELOPMENT

4.1	Introduction		74
4.2	Module Development Model		75
4.3	Stage I: Preparation of the Drafted TEL module		76
	4.3.1	Aim of the Module Setting	76
	4.3.2	Identify the Theory, Target Group and Time	77
		4.3.2.1 Learning Theories	77
		4.3.2.2 Target Group	78
		4.3.2.3 Student's Learning Time	79
	4.3.3	Research Needs on Teachers	81
	4.3.4	Goal Settings	86
	4.3.5	Content Selection	87
	4.3.6	Strategy Selection	90
	4.3.7	Logistic Selection	91
	4.3.8	Media Selection	100
		4.3.8.1 Interactive Design	100
		4.3.8.2 Text Content	104
		4.3.8.3 Graphic	105
	4.3.9	Module Combination Process	107
4.4	Stage II: Evaluation and Implementation of the TEL Module		108
	4.4.1	Evaluation I: Validity and Reliability of the TEL Module	109

	4.4.2	Evaluation II: Experimental Research in a Laboratory Setting	111
4.5	Summary		113
CHAPTER 5: DATA ANALYSIS AND FINDINGS			114
5.1	Introduction		114
5.2	Validity and Reliability of the TEL Module		115
	5.2.1	Content Validity of TEL Module	116
	5.2.2	Face Validity of TEL Module	118
5.3	Module Reliability		119
5.4	Effectiveness of TEL module		119
	5.4.1	Null Hypothesis 1 ($H_0$1)	120
	5.4.2	Null Hypothesis 2 ($H_0$2)	121
5.5	Summary		122
CHAPTER 6: DISCUSSION, IMPLICATION AND RECOMMENDATION			123
6.1	Introduction		123
6.2	Discussion		124
6.3	Research's Implication		129
6.4	Conclusion		130
6.5	Recommendation for Further Research		132
6.6	Summary		134
REFERENCE			135
APPENDICES			146

LIST OF TABLES

Table No.		Page
1.1	The Grading System for SPM	16
1.2	Cronbach's Alpha for Reliability Coefficient of the Module	19
3.1	The Pre-test and Post-test Control Group Design	43
3.2	The Experts' Profile of Content and Face Validity of the TEL Module	53
3.3	The Rating Scale for the Module Validation	54
3.4	Summary of the TEL Module Intervention	63
3.5	T-Test for Equality of Mean	70
3.6	The Hypotheses, Instruments and Corresponding Analysis	72
4.1	Topics of Waves and Sound in the TEL Module and corresponding Learning Time	80
4.2	Frequencies for The Most Difficult Physics Chapters	84
4.3	Mean Value for Each Construct	85
4.4	Topics of Waves and Sound in the TEL Module	88
4.5	Icons and Responds in TEL module	106
5.1	Evaluation of Module's Content Validity by the Experts	116
5.2	Evaluation of Module's Face Validity by the Experts	118
5.3	Alpha Cronbach's Value for the TEL Module	119
5.5	Result of Independent Sample T-Test	120

5.6 Result of Paired-sample T-Test 121

LIST OF FIGURES

No. Figures		Page
1.1	Formula for Content Validity Achievement	17
1.2	Conceptual Framework	20
2.1	Flow of the reinforcement. Adapted from Gagne, 1974	35
3.1	Flowchart of Sideks' Module Development Model (2005)	41
3.2	Flow Chart of the Research Procedure	45
3.3	Sampling of Students Involved in This Study	48
4.1	Launching the VA Installed Program	92
4.2	The Interface and Function in the VA	93
4.3	Installing Tracker	94
4.4	Icon of the FSG in the Play Store	95
4.5	Interface of the FSG	97
4.6	Interface of Advanced Spectrum Analyzer	98
4.7	Interface of the Chromatic Tuner	99
4.8	TheVisual Stimulation in 'Mindful Reading'	101
4.9	Graph display in Self-Learning Module	102
4.10	Links to YouTube in 'Funtastic Physics'	103
4.11	The Icon of 'Physics Lab'	104
4.12	The Flow Chart of Sideks' Module Evaluation Process	108

4.13	Students are Assisted by the Teacher in the Process of Experimenting	110
4.14	Students Explore and Demonstrate the Experiment.	110
4.15	Implementation of TEL Module in the Learning Environment	112

LIST OF GRAPHS

No.	Graphs	Page
3.1	Normal Q – Q plot showing correlation between observed and expected value of pre-test for controlled group	66
3.2	Normal Q – Q plot showing correlation between observed and expected value of post-test for controlled group	67
3.3	Normal Q – Q plot showing correlation between observed and expected value of pre-test for experiment group	68
3.4	Normal Q – Q plot showing correlation between observed and expected value of post-test for experiment group	69

LIST OF ABBREVIATIONS

4Cs	Communication, Critical Thinking, Collaboration & Creativity
ASA	Advanced Spectrum Analyzer
CRO	Cathode Ray Oscilloscope
ICT	Information and Communication Technology
IPS	Institute of Graduate Studies
KSSM	*Kurikulum Standard Sekolah Menengah*
LPM	Malaysia Examination Syndicate
MOE	Ministry of Education
PPPM	*Pelan Pembangunan Pendidikan Malaysia*
SMK	*Sekolah Menengah Kebangsaan*
SPM	*Sijil Pelajaran Malaysia*
SPSS	Statistical Package for Social Science
TEL	Technology-Enhanced Learning
TOT	Training of Trainers
UPSI	*Universiti Pendidikan Sultan Idris*
VA	Visual Analyzer
ZPD	Zone of Proximal Development

LIST OF ATTACHMENTS

A	Permission Letter for Conducting Research
B	Self-Learning TEL Module and QR code
C	TEL Experiment Manual and QR code
D	Test Specification Table
E	Achievement Test on the Topic of Sound Waves
F	Face Validity Form for TEL module
G	Report of Face Validity Form for TEL module
H	Content Validity Form for TEL Module
I	Report of Content Validity Form for TEL module
J	Face Validity Form for Achievement Test
K	Report of Face Validity Form for Achievement Test
L	Content Validity Form for Achievement Test
M	Report of Content Validity Form for Achievement Test
N	TEL Modules' Reliability Agreement Form
O	Report of TEL Modules' Reliability Agreement
P	Questionnaire of TEL Modules' Reliability
Q	Daily Lesson Plan
R	KSSM Physics Syllabus in the Topic of Sound and Waves
S	Controlled Group Tools of Teaching and Learning

CHAPTER 1

INTRODUCTION

1.1 Research Background

Educating pupils and generating them to become potentially high quality generation in the 21st century globalisation has become a very important norm nowadays. Hence, Ministry of Education (MOE) has introduced *Pelan Pembangunan Pendidikan Malaysia* (PPPM) 2013-2025 and 21st Century learning to be aligned with the idea which focuses on aspects of skills and competencies.

There are four basic principles in the process of planning and implementing 21st century learning which includes student-centered, collaborative and contextual learning to integrate with the community. Teachers should integrate 21st century pedagogy with creativity, innovative and critical thinking skills which emphasise on problem-solving and decision making ability towards the 21st Century pedagogy practices (Osman & Basar, 2016).

The 21st Century learning focuses on the four skills that should be acquired by pupils, namely communication, critical thinking, collaboration and creativity (4Cs). The responsibility of fostering the 4Cs in 21st Century learning skills is very important to achieve the vision of PPPM 2013 – 2025. All the teachers also play the main role in carrying out the responsibility. Knowledge should be delivered coherently with pupils learning activities (Azmi & Nurzatulshima, 2017).

The growth in Information, Communication and Technology (ICT) has attracted the attention of teachers worldwide to adopt ICT skill in their teaching and learning. Integrating technology in the classroom helps one to expand their knowledge and developing their 21st century skills.

A study by Rusdin (2018) indicates that teachers are good at creating learning activities that promote creativity, problem-solving, communication and collaboration with high agreement but show moderate agreement in promoting innovation and critical thinking skills. A research carried out by Osman and Basar (2016) has withdrawn the

same result that teachers face the most challenges in fostering innovation and critical thinking compared to other skills.

Effective teaching methods play important roles in promoting students' ability to understand the concept and skills they required. Salehudin, Hasan and Hamid (2015) suggest that a new teaching direction will enhance understanding of the students. Teachers should change the form of teaching from the traditional method to pupil-centered which focuses on higher thinking skills and ICT based self-learning. Misconception about Physics will persist if teachers do not adopt a different approach to their professional development (Daud, Karim, Hassan & Rahman, 2015). As we focused on the concept of waves, students interpret sound as a material and this wrong concept also occurs with the concept of sound waves (West & Wallin, 2013). When it comes to practical works, some laboratory equipment is dormant thus it is not suitable for use. The reason behind this is because too many tools are not functioning or they are damaged because of poor laboratory management (Mahanani, Wening, Susanto & Sudirman, 2020).

American Lab Report (2016) quote that the undergraduate education of potential science teachers at present does not train them for successful laboratory teaching. Undergraduate science departments seldom have laboratory environments for potential science teachers. Once on the job, they have few chances to improve their teaching in the laboratory. Professional development resources are limited in consistency, availability and place little emphasis on laboratory instruction.

Jaafar et al. (2016), Zainal Abidin and Tho (2018) used smartphones to generate sound wave, frequency meter or oscilloscope for sound wave experiments. The utilisation of smartphone in laboratory during experiment supports a study by Mohamad (2012) which stated that mobile learning facilitates the tasks of teachers, minimizes the time allocation of teachers in preparing teaching aids and it is a helpful learning tool for students (Nail & Ammar, 2017). The Visual Analyzer, VA and spectrum analyzers from smartphone application store can optimally impact student learning when teachers are digitally literate and understand how to integrate it into the curriculum. Learning through this medium enable a more engaging learning experience for students to increase their motivation and achievements and to protect them from the negative effects of the rote-memory-based education system (Serin, 2011), which emphasis relevance and encourage inquiry-hands-on instruction (Applebaum, Vitale, Gerard & Linn, 2017).

Technology has taken over every aspect of life for efficiency in time, space and location. Therefore, the key to successful integration of technology together with constructivism theory; whether explaining the theory or conducting experiments, teachers need to learn the technology for teaching and learning purposes.

1.2 Problem Statement

In the current education scenario, KPM recognizes the critical role of 21st Century teaching-learning method especially ICT infrastructure and internet connectivity in educational institutions (Garba, Yusuf & Busthami, 2015). The integration of technology in learning science incorporates laboratory experience results in one of the science learning goals which provide technology-enhanced learning for mastery of subject matter. Thus helping it in the construction of scientific knowledge and understanding. Computer-based simulations and representations are more likely to be effective in developing scientific reasoning as they may promote the student's ability to relate between theory and observation of phenomena to ultimately generate a conclusion (Peffer, Beckler, Schunn, Renken, & Revak, 2015). As a result, the desired student's achievement will increase as the product of the student's interest and understanding of science.

In attempts to aid students with 21st Century skills, limited teaching time is a challenge (Yunos, 2015) and worsens with deficiency, functionless, expensive and complicated measuring instruments in school laboratory (Uba, 2012; Katili, Sadia & Suma, 2013). Effective teaching approaches play an important part in increasing the student's ability to master any skills. However, a study by Rusdin (2018) shows that teachers' understanding related to 21st century skills is at moderate level while they are reported to face the compact curriculum and central exam issues (Saad, Saad & Dollah, 2012). Subsequently, most of the teachers apply the conventional teaching methods until now (Azmi & Nazatulshima, 2017) because they believe teaching by explaining is the

fastest way to cover the extensive curriculum. Mahanani et al. (2020) also include that 50 percent of school teachers have a low category of laboratory knowledge eventhough` 78 percent have a quite good practical teaching experience.

Simanjuntak, Desnita and Budi (2018) found that 99.5 percent of 67 students who owned smartphones are using it more than 4 hours a day after school; which they use to access social media and play games. The study also reported that 64.2 percent of students did not repeat the lesson they had learned at school; one of the reason was that the students did not understand the subject well due to limited time in the classroom and the topic of wave is abstract and difficult to understand if it is only learned in school and need to be repeated outside of the classroom.

There are many research that demonstrate the use of technology especially smartphones and computer applications in teaching and learning (Fitzgerald et al. 2011; Kuhn & Vogt, 2013; Vogt & Kuhn, 2013; Sans et al., 2013; Vieyra & Vieyra 2014; Kuhn, Vogt & Hirth, 2014; Kuhn, Molz, Gröber, & Frübis 2014; Meibner & Haertig, 2014; Klein, Hirth, Gröber, Kuhn, Müller 2014; Azael Barrera-Garrido 2015; Jaafar et al. 2016). However, there is a lack of research that develops a module that contains a collection of technology-enhanced inquiry-based activities on sound waves. In addition, there is none, to the researcher's knowledge, such module being developed that is aligned with the new physics curriculum; *Kurikulum Standard Sekolah Menengah* (KSSM) which to be introduced for Form Four students in the year 2020.

Norlidah Alias and Saedah Siraj (2012) reported that in Malaysia, there was a lack of empirical evidence regarding the effectiveness of a TEL module in concept construction and how it affects students' achievement. Although studies have been conducted on the concepts of learning styles and technology for Biology, however not much has been done on the development of Physics modules.

Prior to the development of the TEL module, the researcher had conducted a need study on 70 Physics teachers in Malaysia. The questionnaire was constructed into three dimensions that consist of 28 questions on the most difficult Physics chapter, the needs for technology and teachers' knowledge of Technology-Enhanced Learning. The result shows that Sound and Waves are among the most difficult Physics chapter to learn besides Electromagnetism and Electricity. Data from a descriptive analysis shows that the level of the need for Technology Hardware and awareness on Technology-Enhanced Learning are moderately high. These findings show that teachers possesses the knowledge and awareness to implement Technology-Enhanced Learning without restriction to time and place.

These facts raises the need to develop a TEL module that can facilitate students to learn Physics' topic of waves and sound independently wherever and whenever it is appropriate. Thus, there is a need to develop a TEL module in the topic of sound waves that can be a reference for Physics teachers in implementing inquiry-based, Technology-Enhanced Learning activities as an alternative to the more traditional lab and direct teaching. The TEL module consists of a self-learning module and experiment manual that

apply the use of smartphone and computer software. It also includes both formative assessment and summative assessment tasks. It can also cater the issues of deficiency, costly and complexity of measuring instruments such as CRO and visual analyzer and time of instruction. By using this module, students should be able to carry out the activities other than in the laboratory and beyond their school hours.

1.3 Objectives

This study consists of three main objectives:

i. To develop a TEL module in the topic of sound waves by utilising free-ware and free smartphones application.

ii. To validate the TEL module.

iii. To determine the effectiveness of the developed TEL module in terms of students' academic achievement.

1.4 Research Questions

This study consists of four research questions:

i. Does the developed TEL module have a good validity?

ii. Does the developed TEL module have a good reliability?

iii. Is there any significant difference between the achievements of the control group who underwent learning conventionally compared to the experimental group who underwent learning using the TEL module?

iv. Is there any significant difference between the achievements of the experimental group before and after undergoing learning using the TEL module?

1.5 Hypothesis

The null hypotheses statement tested in this study are:

$H_0$1: There is no significant difference in the achievements mean scores of the control group compared to the experimental group.

$H_0$2: There is no significant difference in the achievements mean scores of the experimental group before and after undergoing learning using the TEL module.

1.6 Significance of Research

The development of this TEL module enables teachers to foster 4Cs and 21st Century skills. The suggested activities are hands-on where pupils could involve in the activities actively and they get the chance to contribute in achieving activities outcomes. Students cooperate in group activities becomes more independent and autonomous in their learning and this will help teachers promote communication and collaboration skills.

Besides hands-on activities, the TEL module also offers technology-based activities since TEL skills are one of the 4Cs skills. The hands-on and technology-based activities in the module can promote pupils' creativity, innovation and problem-solving skills.

The developed TEL module will provide opportunities for the physics teacher to enrich their knowledge and increase their capability in exploring the technology-enhanced pedagogy in promoting creativity in planning effective, meaningful and fun teaching techniques.

Teachers need resources and references to support their teaching, thus the developed TEL module will benefit Physics teachers, lecturers and educators in terms of having an alternative pedagogy to teach the topic of waves and sound through inquiry-based learning. The scaffolding in the TEL module is a new approach when technology-enhanced learning by using everyday gadgets can be used to experiment with waves and sound waves phenomena.

Physics teachers, supervisors, Physics curriculum expert are welcome to review and reconstruct the Physics Curriculum as the teachers cannot stand alone in implementing effective 21st Century learning. The module is practical and teachers can use the suggested activities immediately. In addition, teachers can adopt or adapt the suggested activities to new activities to make it meaningful in their teaching.

The developed TEL module will provide the feedback to the decision-maker to develop more technology-enhanced modules towards the effective methods in teaching waves and sound in also to provide the infrastructure needed to implement constructive inquiry-learning.

1.7 Research scope

This research focuses on the topic of waves and sound in KSSM Form 4 Physics syllabus. This topic is chosen because the experiment on this topic is a challenge to the teachers in terms of handling the frequency generator to produce frequency. By using the TEL module, students will be able to observe the parameters of waves generated by sound such as frequency, wavelength and period of oscillation. As the students build the conceptual construction of waves and sound, they investigate the properties of sound waves such as reflection, resonance, interference and determine the speed of sound indirectly from the graph plotted when relating the parameters in sound waves interference. This research sample consists of 60 female Form Four Physics students in Ipoh. The research is done in three weeks. Data of this research can only be generalized for the identified population and the topic of waves and sound.

1.8 Definition of Terms

There are three definitions of terms discussed which are Technology-Enhanced Learning, Visual Analyser and Sound Waves.

1.8.1 Technology-Enhanced Learning

Technology-Enhanced Learning (TEL) is an integration of a teacher's practices and pedagogically enhanced with suitable technological tools to achieve the objectives of learning to increase students' understanding and experience. Schweighofer and Ebner (2015) refer TEL as all possible ways to utilise technology in teaching and learning.

The definition of Technology-Enhanced Learning is defined as the group of all approaches in which technology is used to aid the learning or teaching process (Dror, 2008) for the purpose of motivating and engaging the learner. Hence, by the definition described earlier by Schweighofer and Ebner (2015), the study on TEL module is limited to computer-based software and smartphone application.

1.8.2 Visual Analyzer (VA)

Visual Analyzer (VA) is real-time software, which is a complete set of measuring instruments with the use of hardware such as speaker and microphone. VA has been used as basic measurements software which is capable to measure the input of amplifiers, transformers and loudspeaker.

VA simulates a set of electronic instruments, such as the oscilloscope, spectrum analyzer, waveform generator, frequency meter and voltmeter. It is also able to filter data log and screenshot of Spectrum and Scope window, analog conversion, frequency compensation, unlimited frequency sampling and many more.

To install VA into computers or laptops, there are three different kinds of download which are; Download a single setup file, Download only the VA.exe file and Download ISO image. The brief tutorial on downloading the VA can be found at the developer website http://www.sillanumsoft.org/download.htm and installed in Window-based computer.

1.8.3 Sound Waves

In Physics, a sound wave is a mechanical wave that results from the movement of particles of the medium through which the sound is moving. The movement of energy which travels through a medium such as air, water, or any other liquid or solid matter creates the pattern of disturbance. An example of the source of sound waves is the vibration of a human's vocal chords which produce voice. On the other hand, humans only can hear sound waves when the frequency is in the range between 20 Hz and 20 kHz.

In the TEL develop module, the properties of sound include all the characterised generic properties of sound waves such as frequency amplitude, speed of sound, reflection, interference and resonance.

1.9 Operational Definitions

The operational definition discussed in this section is Achievement, Validity of TEL module and Reliability.

1.9.1 Achievement

The objective of this study is to obtain the test result in the achievement test which has been prepared and designed by the researcher. This results in the form of a percentage of achievement scores in an indicator of the effectiveness of the TEL module and the teaching method on the sample. The form four KSSM students' achievement is measured based on the SPM grading system. Table 1.1 shows the grading system for SPM.

Table 1.1

The Grading System for SPM

Scores (%)	Grade	Status
80-100	A+	Super Distinction
75-79	A	High Distinction
70-74	A-	Distinction
65-69	B+	Super credit
60-64	B	High credit
55-59	C+	Upper credit
50-54	C	Credit
45-49	D	Upper pass
40-44	E	Pass
0-39	G	Fail

Resources from Ministry of Education

1.9.2 Validity of TEL module

There are two types of validity in this research, which are face validity and content validity.

To obtain the content validity of the TEL module, the modules are referred to the specialist who has expertise in the field are of Physics Education and module designing. Each expert has been appointed by Institute of Post Graduate (IPS) to evaluate the content validity of the TEL module along with questionnaires. A total of three experts evaluate the content validity of the TEL module. The result of the assessment made by experts shows a high degree of validity of more than 70% or 70 coefficients. Sidek and Jamaluddin (2005) formulated a formula to calculate the content validity achievement from each expert in Figure 1.1.

$$\frac{\text{Total Score from Expert (x)}}{\text{Maximum Score (100)}} \text{ x } 100\% = \text{Content Validity Achievements}$$

Figure 1.1 Formula for Content Validity Achievement

1.9.3 Reliability of TEL module

Reliability of the TEL module is the degree of agreement between the users of the module in terms of to what extent the module enables the users to achieve the module's objectives and implement the suggested activities.

The reliability of the TEL module is measured based on the reliability of a self-developed questionnaire in which the items indicates the achievement of the module's objectives and successful implementation of the suggested activities.

In statistics, the alpha coefficient by Cronbach (1951) is the most popular method of testing for reliability and it coefficient ranges from 0 to 1. The higher Cronbach's alpha coefficient indicates the greater the internal consistency of the items that is the set of items are closely related as a group. Table 1.2 shows the rules of thumb provide by George and Mallery (2010):

Table 1.2

Cronbach's Alpha for Reliability Coefficient of the Module

Coefficient	Reliability Level
0.91 or greater	Excellent
0.81 – 0.90	Good
0.71 – 0.79	Acceptable
0.61 – 0.70	Questionable
0.51 – 0.60	Poor
0.00 – 0.50	Unacceptable

1.10 Conceptual Framework

Figure 1.2 shows the conceptual framework for the research. It is focused on developing a Teaching and Learning Module which has been verified with face validity and content validity. The reliability of the module is obtained from the pilot test. The effectiveness of the module is determined with the achievement test which is given to the students before and after the implementation of the TEL module.

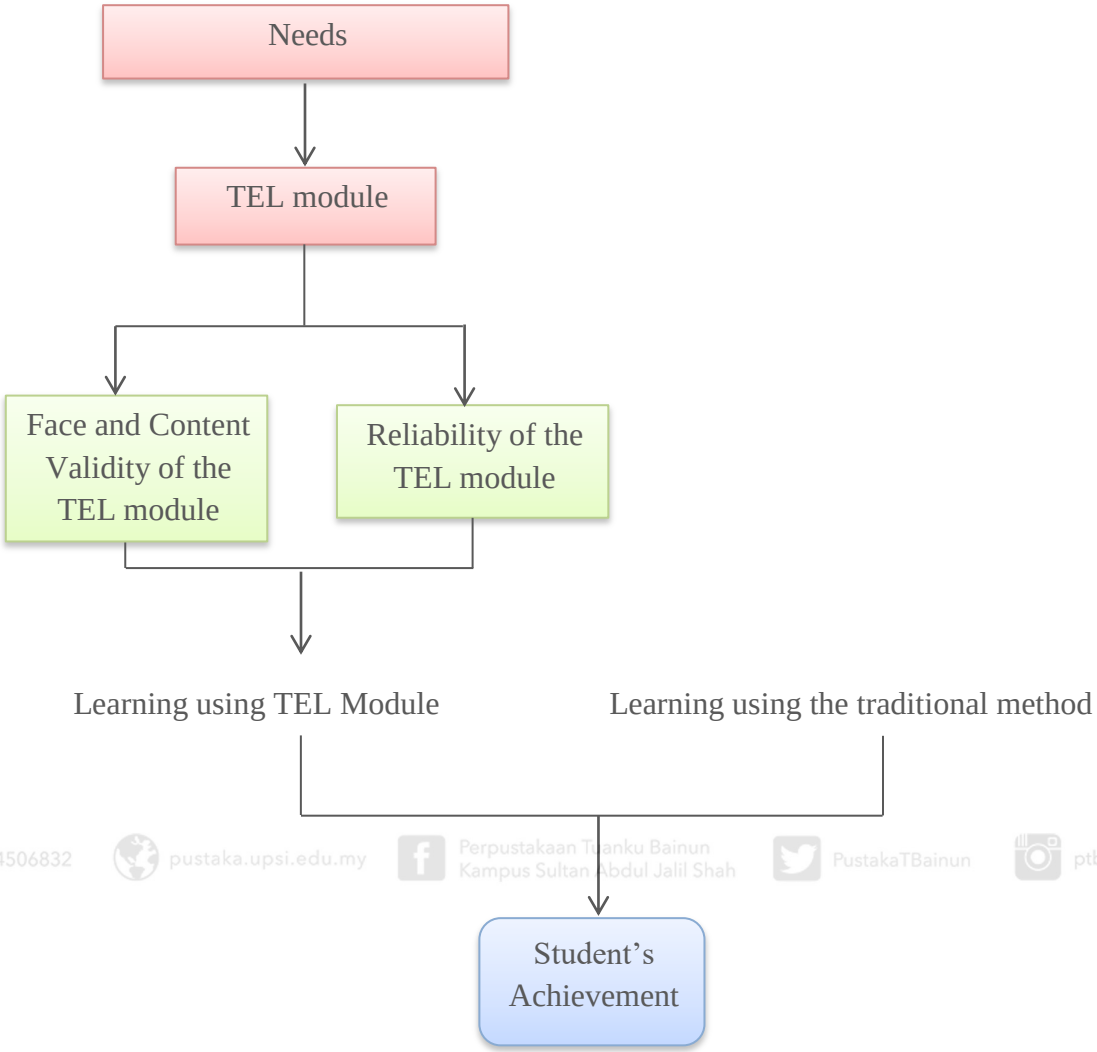

Figure 1.2. Conceptual Framework

Based on Figure 1.2, the teaching Module is developed to enhance students' understanding of the sound wave. Before this module is developed, the developer analyses the needs of TEL module and its face validity and content validity were determined. This module also determines the value of its reliability. Students'

understanding is measured through achievement test scores given before and after the learning activities.

1.11 Summary

Teaching and learning sound waves can both be challenging when there are too many variables involved in an experiment. Teachers faced some constraints involving deficiency of measuring instruments and also restricted teaching time to the teacher and learning time – for students. Thus, technology is nevertheless the alternative for the teachers to help students to observe the sound waves in a way to build a better conceptual construction.