THE DEVELOPMENT AND EVALUATION OF A LAB REPORT SCORING CHECKLIST TO ASSESS THE PRACTICAL SKILLS INDIRECTLY IN AN UNDERGRADUATE OPTICS COURSE

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

MUHAMAD ZULHELMI BIN OTHMAN

UNIVERSITI PENDIDIKAN SULTAN IDRIS

2023

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

THE DEVELOPMENT AND EVALUATION OF A LAB REPORT SCORING CHECKLIST TO ASSESS THE PRACTICAL SKILLS INDIRECTLY IN AN UNDERGRADUATE OPTICS COURSE

MUHAMAD ZULHELMI BIN OTHMAN

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

FACULTY OF SCIENCE AND MATHEMATICS
UNIVERSITI PENDIDIKAN SULTAN IDRIS

2023

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

UNIVERSITI PENDIDIKAN SULTAN IDRIS
SULTAN IDRIS EDUCATION UNIVERSITY

Sila tanda (√)	
Kertas Projek	
Sarjana Penyelidikan	√
Sarjana Penyelidikan dan Kerja Kursus	
Doktor Falsafah	

INSTITUT PENGAJIAN SISWAZAH

PERAKUAN KEASLIAN PENULISAN

Perakuan ini telah dibuat pada 11 (hari bulan) 4 (bulan) 2023

i. Perakuan pelajar :

Saya, MUHAMAD ZULHELMI BIN OTHMAN (SILA NYATAKAN NAMA PELAJAR, NO. MATRIK DAN FAKULTI) dengan ini mengaku bahawa disertasi/tesis yang bertajuk THE DEVELOPMENT AND EVALUATION OF A LAB REPORT SCORING CHECKLIST TO ASSESS THE PRACTICAL SKILLS INDIRECTLY IN AN UNDERGRADUATE OPTICS COURSE adalah hasil kerja saya sendiri. Saya tidak memplagiat dan apa-apa penggunaan mana-mana hasil kerja yang mengandungi hak cipta telah dilakukan secara urusan yang wajar dan bagi maksud yang dibenarkan dan apa-apa petikan, ekstrak, rujukan atau pengeluaran semula daripada atau kepada mana-mana hasil kerja yang mengandungi hak cipta telah dinyatakan dengan sejelasnya dan secukupnya

Tandatangan pelajar

ii. Perakuan Penyelia:

Saya, SITI NURSAILA BINTI ALIAS (NAMA PENYELIA) dengan ini mengesahkan bahawa hasil kerja pelajar yang bertajuk THE DEVELOPMENT AND EVALUATION OF A LAB REPORT SCORING CHECKLIST TO ASSESS THE PRACTICAL SKILLS INDIRECTLY IN AN UNDERGRADUATE OPTICS COURSE (TAJUK) dihasilkan oleh pelajar seperti nama di atas, dan telah diserahkan kepada Institut Pengajian Siswazah bagi memenuhi sebahagian/sepenuhnya syarat untuk memperoleh Ijazah SARJANA PENDIDIKAN (FIZIK) (SLA NYATAKAN NAMA IJAZAH).

28/7/2022

Tarikh

Tandatangan Penyelia

DR. SITI NURSAILA ALIAS
Pensyarah Kanan
Jabatan Fizik
Fakulti Sains dan Matematik
Universiti Pendidikan Sultan Idris

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

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 AND EVALUATION OF A LAB REPORT SCORING CHECKLIST TO ASSESS THE PRACTICAL SKILLS INDIRECTLY IN AN UNDERGRADUATE OPTICS COURSE

No. Matrik /*Matric's No.*: M20202001353

Saya / *I* : MUHAMAD ZULHELMI BIN OTHMAN

(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 restricted information as specified by the organization where research was done.*
√	TIDAK TERHAD / *OPEN ACCESS*	

(Tandatangan Pelajar/ Signature)

DR. SITI NURSAILA ALIAS
Pensyarah Kanan
Jabatan Fizik
Fakulti Sains dan Matematik
Universiti Pendidikan Sultan Idris

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

Tarikh: 26/7/2022

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

Firstly, thanks to Allah S.W.T because with His bounty and grace, I could complete this dissertation in the allotted time. I have finished the dissertation writing as the preliminary study of developing a lab report scoring checklist to assess the practical skills indirectly in an undergraduate optics course. In extending research, this tool may be used in other courses and enlighten others on the importance of practical skills assessment. These works can be done because of the bits of help of several parties. The highest appreciation to my supervisors, Dr. Siti Nursaila Alias and Assoc. Prof. Ts. Dr. Shahrul Kadri Ayop, who always provide guidance, support, and encouragement throughout the production of this project. They are my inspirations, teachers, and second parents throughout this study. I also would like to thank Universiti Pendidikan Sultan Idris (UPSI) for supporting me financially through Skim Pelajar Holistik. Furthermore, many thanks are also extended to all physics lecturers and colleagues in the Universiti Pendidikan Sultan Idris physics program. I have received a lot of support and solid cooperation from them to make this project successful. Lastly, I would like to thank all my family members for encouraging me throughout my studies and those who were directly or indirectly involved in the success of this project. All of your contributions are greatly appreciated, and may Allah S.W.T bless us all. Thank you again

ABSTRACT

This study was carried out to develop and evaluate the practicality of a lab report scoring checklist to assess practical skills indirectly in the undergraduate optics course (UOC). The study employed quantitative approach with the support of qualitative data. A scoring checklist was developed for the obtained context from the needs analysis using the ADDIE instructional design model. The checklist was validated by six experts from the physics and physics education fields. The face validity was analysed using descriptive statistics, while the content validity was analysed using the Content Validation Index (CVI). The pilot test was conducted in three cyclic processes to obtain the reliability of the developed checklist. It involved three raters from different educational levels who evaluated 35 UOC lab reports. The first stage involves the analysis of inter-rater agreement using Fleiss' kappa coefficient. Next, the Cohen's kappa analysis was employed to determine the reliability of inter-rater agreement for each cycle. After that, the practicality of checklist was evaluated by two lecturers while marking 32 UOC lab reports. The instrument practicality was analysed using descriptive statistics. Findings indicated that the developed scoring checklist had satisfactory face validity, content validity (SCVI/Ave = 0.98, SCVI/UA = 0.87), inter-rater agreement, and test-retest reliability. The checklist also obtained satisfactory practicality level among course lecturers. As a conclusion, a lab report scoring checklist with satisfactory validity, reliability and practicality level to assess indirect practical skills in UOC has been successfully developed in this study. This study implies that the developed checklist could overcome the practical skill assessment loads faced by the UOC lecturers, guides the students in writing a professional lab report and proves that the indirect assessment can be utilised to assess practical skills in the physics laboratory.

PEMBANGUNAN DAN PENILAIAN SENARAI SEMAK PEMARKAHAN LAPORAN MAKMAL UNTUK MENTAKSIR KEMAHIRAN PRAKTIKAL SECARA TIDAK LANGSUNG DALAM KURSUS OPTIK PRASISWAZAH

ABSTRAK

Kajian ini dijalankan bertujuan untuk membangun dan menilai kepraktisan senarai semak pemarkahan laporan makmal untuk mentaksir kemahiran praktikal secara tidak langsung dalam kursus optik prasiswazah (UOC). Kajian ini menggunakan pendekatan kuantitatif disokong oleh data kualitatif. Satu senarai semak pemarkahan telah dibangunkan untuk konteks yang diperoleh daripada kajian keperluan dengan menggunakan model reka bentuk instruksional ADDIE. Senarai semak tersebut telah disahkan oleh enam orang pakar dalam bidang fizik dan pendidikan fizik. Kesahan muka telah dianalisis menggunakan statistik deskriptif, manakala kesahan kandungan dianalisis menggunakan Indeks Kesahan Kandungan (*content validation index*, CVI). Kajian rintis telah dijalankan dalam tiga proses kitaran untuk memperoleh kebolehpercayaan senarai semak tersebut. Kajian tersebut melibatkan tiga penilai daripada peringkat pendidikan berbeza yang menilai 35 laporan makmal UOC. Peringkat pertama melibatkan analisis persetujuan antara penilai menggunakan pekali Fleiss' kappa. Kemudian, analisis Cohen's kappa digunakan untuk menentukan kebolehpercayaan persetujuan antara penilai bagi setiap kitaran. Setelah itu, kepraktisan senarai semak telah dinilai oleh dua pensyarah kursus ketika menanda 32 laporan makmal. Kepraktisan instrumen itu telah dianalisis menggunakan statistik deskriptif. Dapatan kajian menunjukkan senarai semak pemarkahan yang dibangunkan mempunyai kesahan muka, kesahan kandungan (SCVI/Ave = 0.98, SCVI/UA = 0.87), persetujuan antara penilai dan kebolehpercayaan uji-uji semula yang memuaskan. Senarai semak tersebut juga memperoleh tahap kepraktisan yang memuaskan dalam kalangan pensyarah-pensyarah kursus. Sebagai kesimpulan, satu senarai semak pemarkahan laporan makmal yang mempunyai tahap kesahan, kebolehpercayaan dan kepratisan yang memuaskan untuk mentaksir kemahiran praktikal secara tidak langsung dalam UOC telah berjaya dibangunkan dalam kajian ini. Kajian ini memberi implikasi bahawa senarai semak yang telah dibangunkan dapat mengatasi beban pentaksiran kemahiran praktikal yang dihadapi oleh pensyarah UOC, membimbing pelajar menulis laporan makmal yang profesional dan membuktikan bahawa kaedah penilaian secara tidak langsung boleh digunakan untuk menilai kemahiran praktikal dalam makmal fizik.

CONTENTS

	Page
DECLARATION OF ORIGINAL WORK	ii
DECLARATION OF DISSERTATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
CONTENTS	vii
LIST OF TABLES	xii
LIST OF FIGURES	xv
LIST OF ABBREVIATIONS	xvii
LIST OF APPENDICES	xviii
CHAPTER 1: INTRODUCTION	
1.1 Introduction	1
1.2 Research Background	2
1.3 Problem Statement	6
1.4 Research Objectives	11
1.5 Research Questions	11
1.6 Research Scope	12
1.7 Research Significance	12
1.7.1 Significant to lecturer	12

1.7.2 Significant to student 13

1.7.3 Significant to other researchers 13

1.8 Operational Definition 14

1.8.1 Development 14

1.8.2 Evaluation 14

1.8.3 Validity 15

1.8.4 Reliability 15

1.8.5 Practicality 15

1.9 Summary 16

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction 17

2.2 Outcome-Based Assessment (OBE) 17

2.3 Assessment of Practical Skills 23

2.4 Assessment Tool 29

2.5 Formative and Summative Assessments 32

2.6 Map Overlay 34

2.7 Learning Theories 36

2.7.1 Cognitive Load Theory 37

2.7.2 Cognitive Theory of Multimedia Learning 39

2.8 ADDIE Model 42

2.9 Conceptual Framework 44

2.10 Summary 46

CHAPTER 3: METHODOLOGY

3.1 Introduction 47

3.2 Research Design 48

3.3 Research Method 48

3.4 Research Population and Sample 49

3.4.1 Lecturer 49

3.4.2 Rater 50

3.5 Research Instrument 51

3.5.1 Instrument for Qualitative Approach 51

3.5.2 Instrument for Quantitative Approach 52

3.6 Validity 53

3.7 Reliability 55

3.8 Research Procedure and Operational Framework 61

3.9 Data Collection Procedure 63

3.10 Data Analysis 65

3.11 Summary 67

CHAPTER 4: DEVELOPMENT

4.1 Introduction 68

4.2 Checklist Development Framework 68

4.3 Analysis Phase 70

4.3.1 Lecturer Interview 71

4.3.2 Document Analysis 74

4.3.3 Student Interview 75

4.4 Design Phase 82

4.5 Development Phase 84

4.5.1 Criteria Identification 84

4.5.2 Expert Validation 89

4.5.3 Pilot Test 89

4.5.3.1 First Cycle: Experiment 1 89

4.5.3.2 Second Cycle: Experiment 2 94

4.5.3.3 Third Cycle: Experiment 3 99

4.6 Implementation Phase 104

4.7 Evaluation Phase 105

4.8 Summary 105

CHAPTER 5: DATA ANALYSIS AND FINDINGS

5.1 Introduction 107

5.2 Objective Findings 1: Checklist Development 108

5.2.1 Criteria Identification 108

5.2.2 Checklist Improvement 120

5.3 Objective Findings 2: Checklist Validity and Reliability 130

5.3.1 Checklist Validity 131

5.3.2 Checklist Reliability 136

5.4 Objective Findings 3: Checklist Practicality 141

5.4.1 Practicality among Raters 141

5.4.2 Practicality among Lecturers 145

5.5 Summary 155

CHAPTER 6: DISCUSSION AND CONCLUSION

6.1 Introduction 157

6.2 Research Summary 158

6.3 Discussion 161

6.3.1 Checklist Development 161

6.3.2 Checklist Validity and Reliability 169

6.3.3 Checklist Practicality 170

6.4 Implications and Recommendations 171

6.5 Conclusion 173

REFERENCES 174

APPENDICES 182

LIST OF TABLES

Table No.		Page
1.1	The list of CLOs in the UOC	7
1.2	The enrollment of UOC students since 2017	8
2.1	The attributes, sub-attributes, and definition of practical skills	22
2.2	The type of practical skills assessment in science-based courses	25
2.3	The type of assessment tools in science-based courses	29
3.1	The practicality form for the rater	53
3.2	The formula of the CVI indices	55
3.3	The highest study level of the raters	56
3.4	The time frame for one reliability cycle	58
3.5	The information of the data analysis for every research objective	65
4.1	The time frame for the checklist development process	70
4.2	The time frame for the analysis phase	71
4.3	Lecturer interview questions	72
4.4	The summary of the interview with lecturers	73
4.5	The participants of the interview and their programmes	75
4.6	Student interview questions	76
4.7	The student's responses to the task management question	77
4.8	The student's responses to the preferred tool for laboratory assessment	79

4.9	The student's responses to comments on the criteria of the current UOC tool	80
4.10	The student's responses to the other effective ways for lab assessment	81
4.11	The list of lab report criteria and the justification of inclusion	85
4.12	The moderation of A12	90
4.13	The moderation of B10	92
4.14	The moderation of A7	95
4.15	The moderation of B1	97
4.16	The moderation of A10	100
4.17	The moderation of B4	102
4.18	Total lab report to be marked for UOC class of semester 2 (2021/2022)	105
5.1	Title criteria	109
5.2	Abstract criteria	110
5.3	Keywords criteria	110
5.4	Introduction criteria	111
5.5	Materials and apparatus criteria	112
5.6	Methodology criteria	113
5.7	Tabulation of data criteria	114
5.8	Graph/ chart criteria	115
5.9	Calculation criteria	116
5.10	Discussion criteria	117
5.11	Conclusion criteria	118
5.12	Reflection criteria	119
5.13	Formatting criteria	120
5.14	The list of adjustments to the criteria during the first moderation	120

5.15	The list of adjustments to the criteria after the first cycle of the pilot test	124
5.16	The list of finalised criteria in the scoring checklist to assess practical skills indirectly among undergraduates in UOC	129
5.17	The items for the face validity form	131
5.18	Score interpretation from Moidunny (2009)	132
5.19	The CVI results for the I-CVI and UA	133
5.20	The S-CVI/Ave and S-CVI/UA results	135
5.21	Kappa statistic interpretation from Landis and Koch (1977), p. 165	136
5.22	The Fleiss' kappa coefficient for the inter-rater agreement	137
5.23	The Cohen's kappa coefficient for the test-retest reliability	140
5.24	The items for the practicality form	142
5.25	The CVI results for the practicality form	143
5.26	The interview questions of practicality	145
5.27	The summary of the lecturer interview on the checklist practicality	146
5.28	The colour code for the output raster cells	153
6.1	The evidence of the developed checklist to comply with the sub-attributes	162

LIST OF FIGURES

Figure No.		Page
1.1	The current hybrid tool of the UOC	10
2.1	The distributions of the ‘Functional Work Skills’ cluster	20
2.2	An example of the map overlay process	35
2.3	A raster overlay map	36
2.4	A memory processing model adapted from Atkinson & Shiffrin (1968)	37
2.5	A Theory of Multimedia Learning model	40
2.6	The ADDIE model	43
2.7	Conceptual framework	45
3.1	The cyclic process of reliability adapted from Kemmis et al. (2014)	57
3.2	The operational framework of the study	62
3.3	The flowchart of the scoring checklist data collection	64
4.1	The checklist development framework	69
4.2	The initial design of the checklist	84
4.3	The first draft of the developed checklist	88
5.1	The criteria for the developed checklist after the first improvement	124
5.2	The boxplot graph for face validity	132
5.3	The boxplot graph for the practicality among raters	144
5.4	An example of the addition between two input rasters	149

5.5	Raster input for Experiment 1	150
5.6	Raster input for Experiment 2	150
5.7	Raster input for Experiment 3	151
5.8	The addition of the input rasters to produce a new output layer	151
5.9	The new output layer of the summed-up rasters	152
5.10	An example of thermal imaging of connective tissue problems research	153
5.11	The colourized output layer	153
5.12	The problem detection tool	154
6.1	The apparatus setup of experiment 2	163
6.2	The methodology of experiment 2	164
6.3	A full mark checklist	165
6.4	The comparison between correct and incorrect graph curves	167
6.5	The comparison between logical and unlogical data	167
6.6	The feedback session with the students via Google Meet	168

LIST OF ABBREVIATIONS

CLO	Course Learning Outcome
DAPS	Direct Assessment of Practical Skills
IAPS	Indirect Assessment of Practical Skills
MQA	Malaysian Qualification Agency
MQF	Malaysian Qualification Framework
OBE	Outcome-Based Education
PF	Course Pro Forma
SPSS	Statistical Package for the Social Sciences
UOC	Undergraduate Optics Course
UOI	University of Interest

LIST OF APPENDICES

A	Course Pro Forma
B	Lab Report Scoring Checklist
C	Expert Validity Form
D	Practicality Form

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes an overview of the study and elaborates on several small subtopics to facilitate the reader's understanding of this research. This chapter contains eight main sections that are well elaborated: (1) research background, (2) problem statement, (3) research objective, (4) research question, (5) research scope, (6) research significance, (7) operational definition, and (8) chapter summary. The research background explains all aspects directly or indirectly involved in this study. The problem statement explains the factors that prompted this study to be carried out based on the issues from the research background. Furthermore, the research objective, research question, and conceptual framework are discussed to determine the direction of the study. Finally, the operational definition and the research significance are also covered in this chapter to justify the research.

1.2 Research Background

In this rapidly developing current of globalization, employment opportunities are very limited. The challenges of the 21st century also demand graduates equipped with adequate skills in the working environment. Instead of choosing graduates for a specific position inside the organization, employers frequently choose graduates based on their perceived general potential (Caballero & Walker, 2010). This employment selection method challenges the traditional education system to change the learning patterns for preparing graduates with work-readiness skills.

In Malaysia, the Malaysian Qualifications Agency (MQA), as the sole national higher education quality assurance organization, facilitates quality by developing the Malaysian Qualifications Framework (MQF), used as a reference point in conducting of the academic program. By the powers granted from the Act of Parliament (Act 679), MQA is responsible for implementing the MQF, accrediting higher education programs and qualifications, supervising and regulating higher education providers' quality and standards, establishing and maintaining the Malaysian Qualifications Register and providing for related matters (Malaysian Qualifications Agency, 2017). Generally, MQA provides a guide to addressing learning outcomes in Malaysian higher institution courses. There are five clusters of learning outcomes that must be included in the course learning outcomes (CLO): (1) Knowledge and Understanding, (2) Cognitive Skills, (3) Functional Works Skills, (4) Personal and Entrepreneurial skills, and (5) Ethics and Professionalism.

According to the Malaysian Qualifications Agency (2017), the cluster of 'Knowledge and Understanding' refers to a systematic comprehension of facts, ideas, information, principles, concepts, theories, technical knowledge, regulations, numeracy, practical skills, abilities to use tools, procedures, and systems. In addition, knowledge is the foundation for all other learning outcomes and can be acquired through formal, informal, and non-formal learning. Next, the cluster of 'Cognitive Skills' is concerned with thinking or intellectual capabilities, as well as the capacity to apply knowledge and skills. The intellectual capabilities help the learner to search for and grasp new information from various fields of knowledge and practices.

The cluster of 'Functional Work Skills' consists of transferable skills that can be used in various workplace environments. The focused skills are 'practical work skills', 'interpersonal skills', 'communication skills', 'digital skills', 'numeracy skills', and 'leadership, autonomy, and responsibility'. The next cluster is 'Personal and Entrepreneurial Skills'. Personal skills are life skills that learners are expected to apply on a regular basis. It includes the capability to make plans for professional advancement or higher education. Entrepreneurial skills involve relevant knowledge, abilities, and expertise in critical enterprise areas. The desire to become an entrepreneur is based on personal skills, but it also requires the acquisition of relevant knowledge, cognitive skills, and functional work skills. The final cluster is 'Ethics and Professionalism'. Ethics includes acceptable behaviour standards and maintaining workplace integrity, while professionalism is more about ethical behaviour in the workplace. Ethics are significant in personal, organizational, community, and global settings because they guide personal actions, interactions at work and within a large community. All these skills are very crucial for work-readiness among graduates. Therefore, higher institutions must emphasise these skills in every offered course to guide the learning process.

Learning is a process that people pass through to others to acquire new knowledge and skills, ultimately influencing their attitudes, decisions, and actions. There are many ways of learning. Science emphasises hands-on learning focusing on inquiry-discovery methods. It involves hypothesis testing, relationship finding, obtaining the relationship between variables, and studying the change of a system with the effect. A hands-on activity in science is often referred to as practical work, experiment, research, or laboratory work conducted in a student-oriented laboratory (Kamarudin & Halim, 2013). In Malaysia, students have been exposed to laboratory work since Standard One in primary school (age of 7). Practical learning is also known as practical work, laboratory work, experiment, and research. It involves the use of laboratory tools, chemical substances, and fresh or preserved specimens. Learning through practicals tends to occur faster than the traditional way because students run their investigation to obtain the information from actual substances (Kamarudin & Halim, 2014).

Physics is a branch of science involving nature, matter, and energy. Although it often involves theories, concepts, laws, and formulas, it is also experimental science. Therefore, laboratory work is the heart of physics (Gkioka, 2019). A specialized Physics subject is offered to Form Four students at the upper secondary level (age of 16) in Malaysia. It is an excellent exposure for students to pursue physics at a higher education level and provides a path to related careers in the future. At the tertiary level, physics laboratory courses have been generally acknowledged as an essential component in the undergraduate curriculum to increase students' understanding of and interest in physics (Wilcox & Lewandowski, 2017).

The most crucial factor influencing learning is what the learner already knows. Teachers should ascertain this and teach accordingly (Ausubel, 1968). In addition, teachers need to be concerned about students' understanding of the subject. That is why an assessment is a critical component of learning. Although laboratory work is practical, it can still be assessed through a medium called a lab report. In Malaysia, a type of practical assessment called *Penilaian Kemahiran Amali* (PEKA) was introduced for Standard 5 students (at age 11) in 2008. PEKA was introduced by the Curriculum Development Division (*Bahagian Pembangunan Kurikulum*, BPK) in the Malaysian Ministry of Education to overcome the problems of weakness in mastering science concepts and science process skills among school students. The implementation of PEKA is also aimed at strengthening students' theories and concepts understanding and knowledge as well as encouraging scientific attitudes and positive attributes (Ishak, 2014). A lab report is essential in every laboratory activity at the tertiary education level. It is often cited as crucial for developing a deeper understanding of science. Traditional laboratory reports usually consist of a title, purpose, procedure, data collected, and answers to conclusion questions. These graded lab reports evaluate the students' ability to follow directions, collect data, and provide the correct answers to conclusion questions (Burrows et al., 2021).

1.3 Problem Statement

Learning outcomes are statements of the knowledge, skills, and abilities individual students should possess and can demonstrate upon completing a learning experience or sequence of learning experiences. The most apparent purpose of learning outcomes used in teaching events is that the students will learn something. Higher education institutions demand that academics specify learning outcomes when they design a module or short course as a component of a degree program is commonplace now (Hussey & Smith, 2008).

In a Malaysian university of interest (referred to as UOI in this study), lecturers will be provided with Course Pro Forma (referred to as PF in this study) for every offered course. It consists of course info, synopsis, names of academic staff, semester and year offered, prerequisite, course learning outcome (CLO), mapping of the course to the program learning outcomes, transferable skill, distribution of student learning time, special requirements, reference, additional information, and verification. The learning outcomes stated in the PF (APPENDIX A) are based on the learning outcomes categorized into five clusters by the Malaysian Qualification Agency (MQA). There are five clusters of learning outcomes: Knowledge and Understanding, Cognitive Skills, Functional Works Skills, Personal and Entrepreneurial skills, and Ethics and Professionalism (Malaysian Qualifications Agency, 2017). All CLOs in a program must cover these clusters to comply with the Malaysian education program standard. Therefore, each course is designed to achieve a set of learning outcomes.

In UOI, most laboratory sessions are fitted into the lecture course. Therefore, the course lecturer is responsible for both lecture and laboratory sessions. An interview session was conducted during needs analysis with several physics lecturers. The result indicates the undergraduate optics course (referred to as UOC in this study) has the largest student enrolment every semester since UOC is a compulsory course for undergraduates taking education programs, major and minor in physics and science fields. Therefore, the UOC is selected as the context of this study. The CLOs for UOC are shown in Table 1.1.

Table 1.1

The list of CLOs in the UOC

Learning Outcome	Item	Domain
CLO1	Apply the knowledge to solve problem examples.	C3
CLO2	Analyse scientific concepts and mathematical knowledge related to course context.	C4
CLO3	Relate the theories and applications to the real physical situation.	A2
CLO4	Perform laboratory exercises and report writings	P3

From Table 1.1, all the CLOs items are mapped according to the learning domains of (1) cognitive, (2) affective, and (3) psychomotor. CLO4 is mapped to cater to psychomotor skills level three, coded as P3, which requires students to perform laboratory exercises and report writings. According to Simpson (1971), P3 is a psychomotor domain under the guided response category. This level is an early stage in learning a complex skill that includes imitation and trial and error. Furthermore, the CLO4 is also mapped to cater to the third Programme Learning Outcome (PLO3), which is in line with the third cluster of the MQF: Practical Skills. PLO3 requires using various technical and manipulative methods and skills to solve physics problems.

Observing students' practical skills in the laboratory can be challenging since practical skills are subjective (Zezekwa & Nkopodi, 2020). Furthermore, this study was conducted during the COVID-19 pandemic, and the movement control order (MCO) required students to perform home-friendly experiments at their homes. Therefore, it is out of the lecturer's view to inspect them. For that reason, a suitable assessment tool that can be used to measure the outline of CLO4 will be very helpful. Furthermore, a generic assessment tool is required to be usable in pandemic and non-pandemic course delivery.

The next problem is the number of students per lecturer. At the higher education level, there was an increase of 22% in student enrolment in 2018 compared to the previous year in Malaysia (Berita Harian, 2018). More students mean more work to be done by the lecturers. For example, at UOI, many students enrol for UOC every semester. The enrolment of the students since 2017 is shown in Table 1.2.

Table 1.2

The enrolment of UOC students since 2017

Session	Semester	Lecturer	Lecture Group	Number of Students	Total
2017/2018	1	L1	A	24	78
			B	30	
			C	24	
	2	L1	A	25	60
			B	35	
2018/2019	1	L3	A	28	103
			B	47	
			C	28	
	2	L3	A	34	159
			B	49	
			C	36	
			D	40	

(*continue*)

Table 1.2 (*continued*)

Session	Semester	Lecturer	Lecture Group	Number of Students	Total
2019/2020	1	L1	A	37	114
			B	39	
			C	38	
	2	L1	A	40	197
			B	38	
			C	39	
			D	39	
		L2	E	41	
2020/2021	1	L1	A	57	178
			B	59	
		L2	C	62	
	2	L1	A	50	150
		L2	B	54	
		L1	C	46	

Based on Table 1.2, there are many students enrolled every semester, yet the lecturer in charge is not that many. During semester 1 (2017/2018), the class size seems acceptable, with about 20 to 30 students per lecture group. However, only one lecturer handled the whole course of 78 students making the learning process quite challenging. The class size increased over time and started to exceed 40 students per lecture group, with more than 100 students per course since semester 1 (2018/2019). During semester 2 (2019/2020), the course achieved the highest enrolment number of students since 2017, with a total of 197 students across all lecture groups. L1 had to handle four lecture groups with about 40 students per group that semester. A ratio of 1:40 makes the teaching and learning process very challenging, even in the secondary or primary school context. Therefore, a suitable assessment that can be applied in large classes is necessary to overcome these problems.

The next problem is the time constraint for the lecturers to evaluate so many students in a laboratory environment. The time provided for the whole teaching and learning process in OUC is 42 hours per semester. However, the time provided for laboratory sessions every semester is only six hours. The UOC has three experiments per semester, meaning only two hours are provided for every experiment. The question is, how can a single lecturer effectively assess the practical skills of 40 students in two hours? Recruiting a teaching assistant may be helpful but costly.

In trying to overcome these problems, the lecturer has developed an assessment tool to assess the students in laboratory assessment. The assessment tool used to mark the lab reports is a hybrid of a checklist and rubric, as shown in Figure 1.1. According to the lecturer, he uses the hybrid assessment tool because it is simple and quick for assessing large classes. Furthermore, the needs analysis findings indicate some problems with the current hybrid tool. Therefore, the current tool is questionable for use in laboratory assessment.

Please self-check on "Student checklist"

	Report check-list	Student checklist [/]	Instructor marks	
1	Maximum 6 pages	☒		1
2	Professional look:	-	-	2
	Consistent font and style	☒		
	Arrangement	☒		
3	Abstract Aim, Methodology & Key Finding)	-	-	3
	1) Aim 2) Methodology 3) Key Finding	☒ ☒ ☒		
4	Keywords	☒		1
5	Introduction	-	-	2
	1) Relevant theory 2) Connection between the theory and the experiment	☒ ☒		
6	Methodology	-	-	2
	1) Labeled figure 2) Correctly described the experiment	☒ ☒		
7	Data table	-	-	4
	1) Correct label using SI unit 2) Consistent decimal point 3) Logical data	☒ ☒ ☒		
8	Graph	-	-	5
	1) Title 2) Appropriate size 3) Axes label 4) Professional look 5) Correct fitting	☒ ☒ ☒ ☒ ☒		
9	Data analysis (Fulfill required task)	☒		6
10	Conclusion(s)	☒		2
11	Reflection	☒		2
		TOTAL		30
	EXACT COPY OF DATA AND REPORT AUTOMATIC ZERO MARK NO PLAGIARISME!			0

Figure 1.1. The current hybrid tool of the UOC

In conclusion, the problem statements in this section have justified the need to conduct this study. Given the nature of the demanding lecturers' teaching load, large class size, limited laboratory session time, and using a questionable assessment tool, developing a valid and reliable scoring tool to assess students' lab reports is a must to overcome these problems.

1.4 Research Objectives

The research objectives are the expected outcomes to be achieved from this study. The following are the research objectives of this study:

1. To develop a lab report scoring checklist to assess practical skills indirectly among undergraduates in UOC.
2. To determine the validity and reliability of the developed checklist.
3. To determine the practicality of the developed checklist.

1.5 Research Questions

In order to achieve the research objectives of this study, the research questions are:

1. What are the suitable criteria in a scoring checklist to assess practical skills indirectly among undergraduates in UOC?
2. Is the validity and reliability of the developed checklist satisfactory?
3. Is the practicality of the developed checklist satisfactory?

1.6 Research Scope

This study is conducted to develop a lab report scoring checklist to assess the practical skills indirectly in an undergraduate optics course. The followings are the research scopes of the study:

1. The lab report scoring checklist is developed based on the study context of UOC only.
2. The validity involves six physics laboratory and education experts.
3. The specimen of this study is the UOC students from semester 2 (2020/2021) to semester 2 (2021/2022) only.
4. The sample is the UOC lecturers interviewed with open-ended questions.
5. The pilot test involves three raters from different study backgrounds that have knowledge of optics.

1.7 Research Significance

In this study, the developed checklist (APPENDIX A) is believed to facilitate the laboratory assessment of the UOC. Therefore, several parties will benefit from this study either directly or indirectly. Therefore, the research significance is:

1.7.1 Significant to lecturer

By developing the scoring checklist, lecturers can use it to evaluate students' lab reports to assess indirectly their practical skills aligned to program standards. Moreover, the developed checklist is valid and reliable, so lecturers can use it without hesitation. Furthermore, the developed checklist involves zero cost, stays within appropriate time constraints, is relatively easy to administer, and has a scoring procedure that is specific and time-efficient, so it is very practical to use by the lecturers. Finally, the proposed method of using the checklist as a problem detection tool is also useful to the lecturers as it can detect specific criteria or group problems, saves time in giving feedback, reflects on the lecturers' practice, and is easily implemented because basic Microsoft Excel skills are the only requirement.

1.7.2 Significant to student

The developed checklist provides guidance for the UOC students to write a professional lab report as work-readiness training. Furthermore, the students will be provided with feedback when using the checklist. Therefore, they can reflect on their practice and improve for the next experiment or future.

1.7.3 Significant to other researchers

This study can be a helpful guide to other researchers who want to conduct a study on developing a lab report scoring checklist. In addition, the development process can guide other researchers in planning to develop an assessment tool in their study context. Finally, the literature review in this study will also benefit other researchers that focus on practical skills assessment.

1.8 Operational Definition

In this section, a few important keywords and terms will be explained based on this study. The keywords are:

1.8.1 Development

The development of a new product is defined as the process of producing or creating something new or more advanced (Oxford University Press, 2022). In this study, development refers to the process of developing a lab report scoring checklist to assess the practical skills in an undergraduate optics course. The scoring checklist focuses on the DAPS method and is developed based on the ADDIE instructional model, which consists of (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation phases.

1.8.2 Evaluation

Evaluation applies scientific methods to action programs to obtain objective and valid measures of what such programs accomplish (Suchman, 1967). In this study, evaluation means the validity, reliability, and practicality processes of the developed scoring checklist. The validity involves six physics laboratory and education experts, the reliability involves three raters from different levels of study background and the practicality involves the sample, which is the UOC lecturers of the current semester. The evaluation of the developed checklist is considered acceptable if the validity, reliability, and practicality achieved some level of satisfaction among the respondents.

1.8.3 Validity

Validity is the degree to which an instrument measures what it is intended to measure. In this study, validity refers to the score given by experts on the content and face validity forms regarding the developed checklist. The face validity contains five items that needed to be scored according to 5 Likert scales, while the content validity contains 47 criteria nested under 13 categories that needed to be scored according to 4 Likert scales. A valid scoring checklist should pass the minimum average score for validity among six experts.

1.8.4 Reliability

Reliability is the degree to which an instrument consistently measures what it is intended to measure. In this study, the reliability is the values of the kappa coefficient for the inter-rater agreement and the test-retest obtained during the pilot test. The inter-rater agreement involves three raters from different levels of study background to mark the same copy of lab reports, while the test-retest involves every rater marking again a randomly chosen lab report at a different time occasion. A reliable scoring checklist should obtain consistent scores among the raters and also within the rater himself.

1.8.5 Practicality

Practical (of things) means useful or suitable (Oxford University Press, 2022). In this study, practicality refers to the scores of practicality form given by the raters after the pilot test. Furthermore, practicality also refers to the lecturers' views about the developed checklist and the proposed method to use the developed checklist as a problem-detection tool. The practicality is determined based on four indicators from Brown (2004), which are (1) cost, (2) time, (3) administration, and (4) scoring. A practical assessment should be inexpensive, stay within a time constraint, easy to administer, and has a scoring procedure that is specific and time-efficient.

1.9 Summary

In this chapter, the problem statements that led to the implementation of this study are justified. There is a need to develop a lab report scoring checklist that can reduce the lecturers' teaching load, be suitable for large class sizes, stay within limited laboratory session time, and back up with solid and extensive academic literature. Three research objectives and questions were developed to determine the goals of this study. Furthermore, the research significance indicates that many parties will benefit directly or indirectly from this study. The following chapter discussed relevant literature reviews to strengthen the goals of this study.