UNIVERSITI PUTRA MALAYSIA

MULTI-PERSPECTIVE USABILITY EVALUATION WITH MULTI-CRITERIA DECISION ANALYSIS FOR OPTIMAL SELECTION OF OPEN-SOURCE SOFTWARE

KAREEM ABBAS DAWOOD

FSKTM 2021 5

MULTI-PERSPECTIVE USABILITY EVALUATION WITH MULTI-CRITERIA DECISION ANALYSIS FOR OPTIMAL SELECTION OF OPEN-SOURCE SOFTWARE

By

KAREEM ABBAS DAWOOD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

February 2021

DEDICATION

This thesis is dedicated to my beloved late mother
أهدي هذا العمل الى نبع الحنان، الى من تعلمت منها الصمود مهما تبدلت الظروف
أمي رحمها الله

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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February 2021

Chairman : Khaironi Yatim Sharif, PhD
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Increasing demand for open-source software (OSS) has raised the neat of efficient selection in terms of quality; usability is an essential quality factor that significantly affects system acceptability and sustainability. Most comprehensive and complex software packages are partitioned across multiple portals and involve many users — each with their own role in the software package. Those users have different perspectives on the software package defined by their knowledge, responsibilities and commitments. Thus, a multi-perspective approach has been used in usability evaluation to overcome the challenge of inconsistency between users' perspectives, which would lead to an ill-advised decision on the selection of a suitable OSS.

This research aims to assist public and private organisations in evaluating and selecting the most-suitable OSS. The selection of the best OSS based on usability evaluation criteria is a challenging task owing to (a) multiple evaluation criteria, (b) criteria importance, and (c) data variation. Thus, it is considered a sophisticated multi-criteria decision making (MCDM) problem.

A generally accepted multi-perspective usability evaluation method for the selection of OSS is unavailable in the existing literature. Hence, this research proposes a methodology for multi-perspective usability evaluation with multi-criteria decision analysis for optimal selection of open-source software. Integration of the best-worst method (BWM) and VIKOR MCDM techniques have been used for weighting and ranking OSS alternatives. BWM is utilised for weighting of evaluation criteria, whereas VIKOR is applied to rank OSS-LMS alternatives. Individual and group decision-making contexts and the internal and external groups' aggregation were used to demonstrate the proposed methodology's efficiency.

A well-organised algorithmic procedure is presented in detail, and a case study was examined to illustrate the validity and feasibility of the proposed methodology. The results demonstrated that the proposed methodology works effectively to solve the OSS selection problem. Furthermore, the ranks of OSS software packages obtained from the VIKOR internal and external group decision making are similar; the best OSS-LMS based on the two ways was 'Moodle'. Among the groups' scores in the objective validation, significant differences were identified, indicating that the ranking results of internal and external VIKOR group decision making were valid, thus validating the proposed methodology.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENILAIAN KEBOLEHGUNAAN MULTI-PERSPEKTIF DENGAN ANALISIS KEPUTUSAN MULTI-KRITERIA UNTUK PEMILIHAN OPTIMAL PERISIAN SUMBER TERBUKA

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Peningkatan permintaan kepada Perisian Sumber Terbuka (OSS) menimbulkan keperluan terhadap pemilihan yang efisyen dari segi kualiti; kebolehgunaan merupakan faktor kualiti utama yang signifikan dalam mempengaruhi penerimaan dan kelestarian. Kebanyakan pakej perisian besar dan kompleks dibahagikan kepada beberapa gerbang dan melibatkan pengguna yang ramai – setiap dari mereka mempunyai peranan di dalam pakej perisian; pengguna-pengguna ini mempunyai perspektif yang berlainan terhadap pakej perisian bergantung kepada pengetahuan, tangungjawab dan komitmen. Maka, pendekatan pelbagai perspektif telah digunakan di dalam penilaian kebolehgunaan bagi mengatasi cabaran ketidakkonsistenan di antara perspektif pengguna, yang akan mengakibatkan keputusan kurang penasihatan di dalam pemilihan OSS yang sesuai. Kajian ini bertujuan untuk membantu organisasi awam dan swasta di dalam menilai dan memilih OSS yang paling sesuai.

Pemilihan OSS terbaik berdasarkan kriteria penilaian kebolehgunaan adalah tugas mencabar disebabkan oleh (a) kriteria penilaian pelbagai, (b) kriteria keutamaan, (c) variasi data; maka, ini adalah masalah pembuatan keputusan pelbagai kriteria yang sofistikated (MCDM). Kaedah penilaian kebolehgunaan pelbagai perspektif yang biasa digunapakai di dalam pemilihan OSS tidak ditemui di dalam literatur sedia ada. Maka, kajian ini mencadangkan penilaian kebolehgunaan multi-perspektif dengan analisis keputusan multi-kriteria untuk pemilihan optimal perisian sumber terbuka. Gabungan Teknik terbaik-terburuk (BWM) dan kaedah VIKOR MCDM telah digunakan bagi mempertimbangkan dan menyusun pilihan OSS. BMW digunakan untuk memberat kriteria kebolehgunaan, manakala VIKOR digunakan bagi menyusun pilihan OSS-LMS. Konteks pembuatan keputusan secara individu dan berkumpulan, and gabungan kumpulan dalaman dan luaran digunakan bagi menunjukkan keefisyenan metodologi yang dicadangkan.

Prosedur algoritmatik yang tersusun dipersembahkan secara terpeinci, dan kajian kes telah diperiksa bagi menunjukkan kesahan dan kebolehlaksanaan metodologi yang dicadngkan. Hasil menunjukkan bahawa metodologi yang dicadangkan berkerja dengan efektif dalam menyelesaikan masalah pemilihan OSS. Tambahan, aturan pakej perisian OSS yang diperoleh dari kumpulan pembuatan keputusan dalaman dan luaran VIKOR adalah sama; OSS-LMS terbaik berdasarkan dua hala adalah 'Moodle'. Di dapati, terdapat perbezaan yang signifikan di dalam markah di antara kumpulan di dalam pengesahan objektif; ini menunjukkan bahawa penyusunan keputusan kumpulan dalaman dan luara VIKOR adalah sah, secara tidak langsung mengesahkan metodologi yang dicadangkan.

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"In the name of Allah, the Most Gracious and the Most Merciful."

Alhamdulillah, first and foremost, praise be Allah, the Cherisher and Sustainer of the World and to the Prophet Muhammad (Peace and Blessings of Allah Be upon Him) who was sent by Allah to be a great teacher to humankind.

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Finally, I express my gratitude to my family for providing me with unfailing support.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

OSS	Open Source Software
ISO	International Organisation for Standardisation
MCDM	Multi-Criteria Decision Making
MCDA	Multi-Criteria Decision Analysis
MCA	Multi-Criteria Analysis
MADM	Multiple Attribute Decision Making
MODM	Multiple Objective Decision Making
VIKOR	Vlse Kriterijumska Optimizacija Kompromisno Resenje
BWM	Best-Worst-method
LMS	Learning Management System
FSF	Free Software Foundation
OSI	Open Source Initiative
FOSS	Free/Open Source Software
FLOSS	Free/Libre/Open Source Software
OSS/FS	Open-Source Software/Free Software
UX	User experience
HCI	Human-Computer Interaction
UCD	User Centre Design
UI	User Interface
SUS	System Usability Score
AHP	Analytical Hierarchy Process
QUIS	Questionnaire for User Interaction Satisfaction
EMR	Electronic Medical Record

e-RUE	Online Remote Usability Evaluation
CVI	Content Validity Index
I-CVI	Item Content Validity Index
S-CVI	Scale-level Content Validity Index
GDM	Group Decision Making

CHAPTER 1

INTRODUCTION

1.1 Background

The purpose of this thesis is to develop a methodology for multi-perspective usability evaluation with multi-criteria decision analysis for optimal selection of open-source software. It is expected that this methodology will help provide proper evaluation and selection of OSS alternative to be adopted by a public or private organisation.

Open-source software (OSS) is software with source code that anyone can use, inspect, modify, and enhance (Çetin & Göktürk, 2008; Joia & dos Santos Vinhais, 2017; Netta Iivari, 2014; Paul, 2009; Raza et al., 2012; Sarrab, 2014). Many organisations have adopted OSS applications due to the significant advantages they offer (Jusoh et al., 2014; Llerena et al., 2019; Nikos Viorres, 2007; Sbai et al., 2018; Sharif et al., 2015). The software's quality is essential when considering which software package to adopt (Côté et al., 2007; Fenton & Neil, 2000; Gupta et al., 2020; Hauge et al., 2010; Kamei et al., 2018). However, although the OSS community has used the peer-review technique to assure OSS quality, there is still a lack of quality assurance, as the participants are often distributed around the world (Bahamdain, 2015; Hauge, 2007; Yusop et al., 2020). Consequently, there may be a risk of neglecting OSS usability, as it is a software quality factor.

The growing use of OSS applications and the increase in the number of non-developer OSS users have created a need for usability attention in the OSS context (Llerena et al., 2019; Netta Iivari et al., 2008; Raza et al., 2012; Sbai et al., 2018). However, usability is an essential quality factor that needs to be considered (Al-Rawashdeh, 2015; Fernández-Pérez et al., 2018; Henrik Hedberg, 2007; Iivari, 2008; Llerena et al., 2019; Rajanen et al., 2012; Rajanen, 2010) since the unusable software is not sustainable (Kamei et al., 2018). Furthermore, usability is a feature associated with software sustainability affecting user acceptance and OSS sustainability(Fernández-Pérez et al., 2018). As one known risk of using OSS applications is OSS sustainability, it would be costly for the organisation if the application breaks midway (Sethanandha et al., 2010).

In an OSS setting, developers generally develop software for self-use; hence, the software is likely to be developed based on their perspective (Llerena et al., 2016; Michael Terry, 2010). Consequently, usability has been paid a little attention, as reported in the studies of Nichols and Twidale (2006), Çetin and Göktürk (2008), Iivari (2008), Capretz (2012), Al-Rawashdeh (2015), Masson et al. (2017), and Llerena et al. (2019) that OSS has poor usability, which limits the adoption of OSS and thus affects its sustainability (Masson et al., 2017). Sustainability is an essential driver for the industry

(Sethanandha et al., 2010). Consequently, usability needs to be investigated (Luyin Zhao, 2010); it is a vital area that deserves a separate study (Çetin & Göktürk, 2008).

According to the International Organisation for Standardisation (ISO), software quality is defined in terms of maintainability, usability, functionality, reliability, efficiency, and portability characteristics (Capretz, 2012; Raza et al., 2011a, 2011b; Standard-9126, 2001). In another study, ISO specifically defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (Abran et al., 2003; Çetin & Göktürk, 2008; Henrik Hedberg, 2007; Iivari, 2008; Rajanen, 2010; Raza et al., 2011a, 2011b). Meanwhile, Luyin Zhao (2010) defines usability as a subtle concept encompassing both task and user characteristics as well as functionality. Unlike functionality, usability is desirable mainly from a user-acceptance perspective, which beliefs it crucial to OSS's ultimate success (Luyin Zhao, 2010; Nielsen, 1992). Eventually, this usability issue suggests the more significant issue of system acceptability and sustainability (Jeddi et al., 2020). Specifically, this raises the question of how effective the OSS is at satisfying users' and other potential stakeholders' needs and requirements (Gupta et al., 2020).

According to Sanga (2010), OSS selection is mostly made by trial and error; if the proposed software does not meet expectations, different software will be identified and offered until most users' requirements are fulfilled. This approach is not suitable due to its subjectivity and the cost in terms of time and expense.

Another significant point is the identical functionality of OSS. This issue arose after many years of development, in which developers produced a vast repository of OSS. Due to developers' common interests and/or motivations, multiple OSS may share identical functionality (Adewumi et al., 2019), which causes problems when selecting the right software package. It is often difficult to find a suitable software package for a specific purpose; to do so, available software packages need to be considered and a method to determine which software package is most appropriate for the user's needs (Adewumi et al., 2019).

The growing numbers of OSS have meant a lack of commonly accepted evaluation criteria, which has become Increasingly challenging for private or public organisation users. The variety of available OSS software packages make it difficult to determine which alternatives – is the most suitable for user needs (Abdullateef et al., 2016; Jusoh et al., 2012; Padayachee et al., 2010; Sbai et al., 2018; Tractinsky, 2018; Zaidan, Zaidan, Hussain, et al., 2015). Therefore, the selection of software that meets users' needs is a challenging process; such a selection process is crucial because the adoption of incorrect software can fail to live up to expectations (Abdullateef et al., 2016; Kannan et al., 2019; Mohammed et al., 2020; Sbai et al., 2018; Zaidan, Zaidan, Al-Haiqi, et al., 2015).

However, since usability is the fundamental factor affecting OSS sustainability and acceptability, and this is a requirement for OSS competing, a few studies have discussed the evaluation of OSS usability (Adewumi et al., 2019; Jusoh et al., 2012; Jusoh et al., 2014; Kannan et al., 2019; Sarrab & Rehman, 2013; Sarrab, 2014; Zaidan, Zaidan, Al-Haiqi, et al., 2015). While these studies present a good insight into the OSS selection evaluation process, they mainly focus on the single user perspective. Hence, this suggests the neglect of other users' viewpoints. Nielsen (1994) reported a critical feature in the same light: usability is measured relative to particular users and particular tasks.; He stated that '"It could well be the case that the same system would be measured as having different usability characteristics if used by different users for different tasks". Nielsen's key point is that the three most essential usability issues are the users' tasks, characteristics, and differences.

Consequently, knowing the users' needs can assist in selecting suitable OSS packages. For the overall acceptability of an OSS package, different users require that their roles and perspectives be synthesised in the software; their knowledge, responsibilities, and commitments determine these roles and perspectives. There have been some active attempts to solve the problem of evaluating and selecting OSS packages, but these interventions have yet to have significant effects (Adewumi et al., 2019; Sbai et al., 2018). Thus, it is necessary to discover a new approach to support users in evaluating and making the best OSS package selection amongst the alternatives (Adewumi et al., 2019). This approach will benefit the community in both public and private organisations.

1.2 Problem Statement

Open-source software (OSS) has recently acquired extensive use, and acceptance across various sectors and organisations (Jusoh et al., 2014; Llerena et al., 2019; Nikos Viorres, 2007; Sbai et al., 2018; Sharif & Buckley, 2009); in contrast, determining which OSS of the alternative software packages is the most appropriate for intended needs is still a challenging process (Adewumi et al., 2019; Jusoh et al., 2012; Sarrab & Rehman, 2013; Sarrab, 2014; Sbai et al., 2018). Consequently, public and private organisations have been facing difficulties in evaluating and ranking the available OSS software packages to determine the most appropriate one (Adewumi et al., 2019; Jusoh et al., 2014; Kannan et al., 2019; Mohammed et al., 2020; Sbai et al., 2018; Zaidan, Zaidan, Hussain, et al., 2015). Despite this, there have been some active attempts to solve OSS's evaluation and selection problems, but these interventions have yet to have significant effects (Sbai et al., 2018). Therefore, a new approach is needed to evaluate and select the best OSS software package from the available alternatives (Adewumi et al., 2019); this will have a practical benefit for stakeholders in public and private organisations. In conclusion, to simplify the complicated problems of OSS evaluation and selection discussed in this section, the following research problems are listed:

Problem 1: Lack of consensus on a specific set of usability criteria to evaluate OSS usability.

Usability is an essential software quality factor that influences user acceptance of OSS (Adewumi et al., 2019; Al-Rawashdeh, 2015; Gupta & Ahlawat, 2017; Gupta et al., 2020; Henrik Hedberg, 2007; Iivari, 2008; Lacerda & von Wangenheim, 2018; Rajanen et al., 2012; Rajanen, 2010) therefore, the usability factor needs to be examined, as software with poor usability will not be sustainable (Henrik Hedberg, 2007; Iivari, 2008; Rajanen et al., 2012; Rajanen, 2010). Furthermore, usability evaluation can guarantee that users' needs and expectations regarding the systems are considered and delivered through allowing completion of their tasks and goals with no adverse outcomes from the OSS usage (Nivala et al., 2008). The most significant step in usability evaluation is determining the proper evaluation criteria. Unfortunately, there is no consensus between scholars and the standards bodies on a specific set of usability criteria to evaluate an OSS (Abran et al., 2003; Lacerda & von Wangenheim, 2018; Sagar & Saha, 2017). Consequently, Tractinsky (2018) suggests that experts need to look for a robust alternative set of evaluation criteria that are yet to be identified; this author, therefore, suggests abandoning or significantly revising the current structure. Moreover, Masson et al. (2017) said an appropriate usability definition recognising that the essential usability evaluation criteria might be used as a guideline for evaluating the software's usability. However, retaining irrelevant criteria and omitting those that are significant will certainly mislead the usability evaluation direction. Therefore, one of the objectives is to identify the most essential OSS usability evaluation criteria to develop a model for usability evaluation.

Problem 2: Evaluating usability based on a single-user perspective while neglecting other users' perspectives.

As mentioned earlier, an OSS software package's overall acceptability depends on its acceptability as rated by the different users. Usability is always related to specific users and the specific tasks they complete within a specific context (Benmoussa et al., 2019; Nielsen, 1994). Evaluations of usability in OSS made by previous researchers, such as Kakasevski et al. (2008), Baytiyeh (2011), Kiah et al. (2014), Laugasson and Mõttus (2015), Othman et al. (2015), Khatun and Ahmed (2018), Adewumi et al. (2019), and Kannan et al. (2019), have focused exclusively on a single-user perspective while neglecting other users' perspectives. As Nielsen (1994) stated, "Usability is measured relative to certain users and certain tasks, [and] it could well be the case that the same system would be measured as having different usability characteristics if used by different users for different tasks". Moreover, as de Almeida Pacheco et al. (2019) have claimed, "Usability is a quality that products should have from the perspective of their users".

Public and private organisations can apply a single-user perspective when implementing a specific software package from a set of alternatives. However, when such a perspective is used, the organisation will inevitably face the different perspectives challenge from

various users who use the same system. This challenge, in turn, potentially creates an inconsistency between users' perspectives, thereby leading to an ill-advised decision about which application system is the most suitable. Therefore, to support the decision-maker in identifying and choosing the most promising and sustainable software package, different users' perspectives must be coordinated required.

The central problem related to evaluating and assessing a set of systems and ultimately selecting the best alternative is referred to as the "multiple perspectives problem". When the multi-perspective evaluation method is applied, inconsistencies can be tolerated and managed by evaluating all application systems based on multiple portal users' perspectives. Therefore, another objective of the present work is to develop a multi-perspective evaluation and decision matrix for OSS usability evaluation.

Problem 3: Ranking and selecting OSS is a challenging process due to the multiplicity of evaluation criteria, data variation, and the relative importance of each criterion.

In spite of the free availability of the OSS, its evaluation and, therefore, the selection is still a challenging process (Abdullateef et al., 2016; Adewumi et al., 2019; Iivari, 2013; Jusoh et al., 2012; Kannan et al., 2019; Sbai et al., 2018; Zaidan, Zaidan, Hussain, et al., 2015). Despite the active attempts to solve OSS's evaluation and selection process problems, these endeavours are yet to produce significant effects(Adewumi et al., 2019). Consequently, public and private organisations have been facing difficulties in evaluating and ranking OSS software packages to determine the appropriate one. Incorrect selection of an OSS application may cause the organisation to face legal accountability and even financial losses if the system fails to live up to the expectations (Abdullateef et al., 2016; Adewumi et al., 2019; Mohammed et al., 2020; Zaidan, Zaidan, Hussain, et al., 2015). The problem of the evaluating and ranking process of OSS is a complicated criteria problem involving potentially competing criteria. More specifically, it is due to the multiplicity of evaluation criteria, data variation, and the importance of each criterion over the other. In other words, one faces the challenges of ranking and then selecting between the OSS alternatives to select the best one. Therefore, the OSS alternatives' evaluation and selection process can be considered multi-criteria decision-making (MCDM) problems(Adewumi et al., 2019). To help the decision-maker select the best OSS alternative, an integrated platform for multi-perspective usability evaluation, for the selection of OSS based on multi-criteria analysis, needs to be implemented, which was not applied in previously studies. Figure 1.1 illustrates the problem statement.

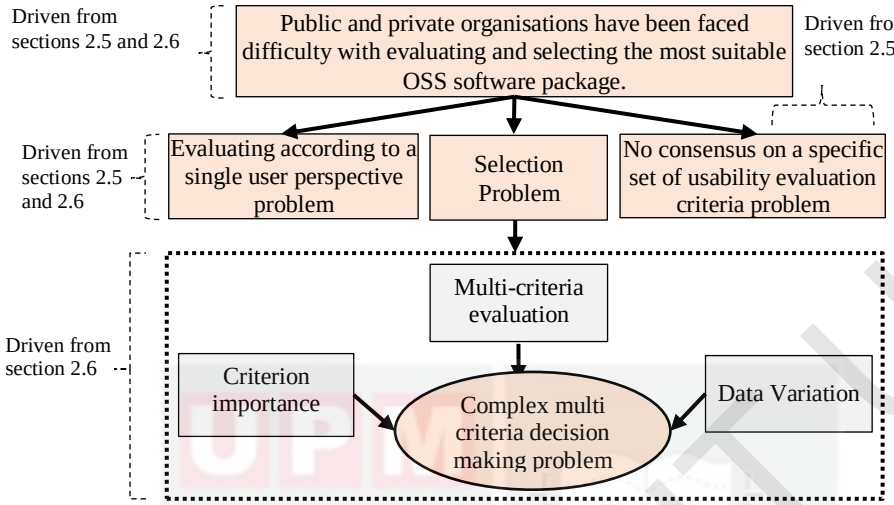

Figure 1.1 : Problem Statement illustration

1.3 Research Questions

In order to set the direction of this research, the following research questions have been drawn up:

- RQ-1 What are the adopted methods and techniques for OSS usability evaluation and selection? And how are they practised in order to evaluate and select the best OSS?
- RQ-2 Which usability criteria are most commonly addressed in various usability models and standards? In other words, to what extent do these criteria affect the evaluation and selection of the best software package?
- RQ-3 What are the adopted usability evaluation perspectives in the process of OSS evaluation?
- RQ-4 How did the researchers integrate the perspectives with the open-source software to evaluate the usability?
- RQ-5 What are the suitable techniques for developing a usability evaluation methodology for the selection of open-source software?
- RQ-6 To what extent are the results of the proposed methodology valid?

1.4 Research Objectives

This study aimed to develop a methodology for multi-perspective usability evaluation with multi-criteria decision analysis for optimal selection of open-source software. Therefore, the objectives of this study are presented as follows:

- To specify the existing methods and techniques on OSS usability evaluation and selection.
- To propose a unified criteria model for usability evaluation in the context of OSS.
- To propose a multi-perspective evaluation and decision matrix for usability evaluation of OSS alternatives.
- To develop and validate the usability evaluation methodology for OSS evaluation and selection.

1.5 Relationship between Research Objectives, Research Questions and Research problem

Research questions were proposed to provide direction and focus on the research, and the research objectives give answers to the research questions. Table 1.1 presents the research questions, and these are then answered by research objectives, as well as it is determining which part of the research problem will be solved when each research objective is achieved.

Table 1.1 : Link among research questions, research objectives and research problem

Research Questions	Research Objectives	Research problem mapping	
		Specific Problem	General problem
RQ-1 What are the adopted methods and techniques for OSS usability evaluation and selection? And how are they practised in order to evaluate and select the best OSS?	• To specify the existing methods and techniques on OSS usability evaluation and selection.	Identify the gap	Selection problem
RQ-2 Which usability criteria are most commonly addressed in various usability models and standards? In other words, to what extent do these criteria affect the evaluation and selection of the best software package?	• To propose a unified criteria model for usability evaluation in the context of OSS.	• Lack of defining the OSS evaluation criteria. • Lack of a unified model is one reason for the usability evaluation problem.	
RQ-3 What are the adopted usability evaluation perspectives in the process of OSS evaluation? **RQ-4** How did the researchers integrate the perspectives with the open-source software to evaluate the usability?	• To propose a multi-perspective evaluation and decision matrix for usability evaluation of OSS alternatives.	• Evaluating according to a single user perspective while neglecting other users' perspectives	
RQ-5 What are the suitable techniques for developing a usability evaluation methodology for the selection of open-source software? **RQ-6** To what extent are the results of the proposed methodology valid?	• To develop and validate the usability evaluation methodology for OSS evaluation and selection.	• Importance of criteria. • Multi-criteria evaluation • Data variation • Validation	

1.6 Scope of the study

This research specify the existing methods and technology on OSS usability evaluation and selection. Thus, this research focuses on developing a usability evaluation methodology for the optimal selection of OSS. This study is limited to evaluating OSS's usability and ranking the alternatives using MCDM methods to select the best one. However, this research does not claim that the usability criteria are only limited to the proposed model's criteria.

The research focuses on proposing a decision matrix intended to evaluate the software package portals separately and independently. The case study that has been used is not the main issue of this study; it is for proof of concept to our proposed methodology. An open-source learning management system (OSS-LMS) has been used as the case study in the experiment to generate the data that is used for proof of concept of our proposed methodology.

1.7 Research Contribution

This research's main contribution is to establish a methodology for multi-perspective usability evaluation with multi-criteria decision analysis for optimal selection of open-source software. This methodology can handle the complicated issues in the selection process of OSS. Furthermore, it can assist the public and private organisation in making the right decision in selecting the suitable OSS software package. Figure 1.2 demonstrates the contribution diagram.

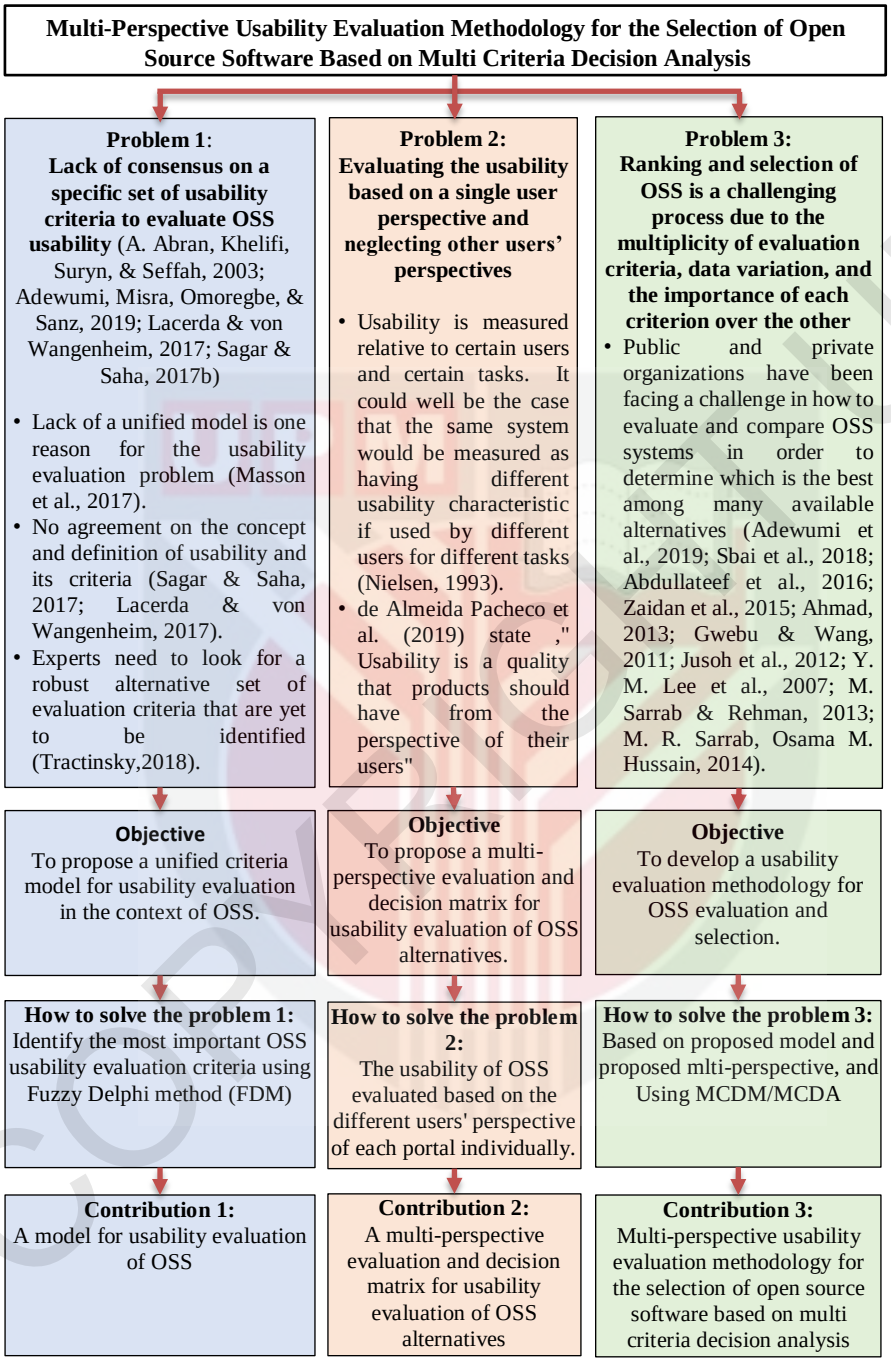

Figure 1.2 : Contribution diagram

1.8 The Organisation of the Thesis

This study is composed of six chapters. Figure 1.3 illustrates the structure of the study. **Chapter One** introduces the research background, research problem, research questions, research objectives, the relationship between research questions, research objective with a research problem, research scope, and the research's significance. Thus, the remainder of this thesis is organised as follows:

Chapter Two – "Literature review" – presents a systematic review of academic literature that focuses on the usability of open source software (OSS). This chapter primarily aims to identify the research gap and challenges and propose recommended solutions.

Chapter Three – "Research Methodology" – describes the requirements for developing the proposed usability evaluation methodology for the optimal selection of open source, as well as the phases involved. The methodology is designed in four key phases: investigation phase, proposed usability evaluation model phase, proposed multi-perspective evaluation and decision matrix phase, and development and validation phase. Through the phases, this chapter will illustrate in detail how the four research objectives will be achieved.

Chapter Four: Proposed Usability Evaluation Methodology for optimal Selection of OSS. This chapter outlines the steps to carry out the proposed usability evaluation methodology for selecting OSS (open-source software). The methodology includes a multi-perspective evaluation and a decision matrix for the usability evaluation of OSS alternatives and the adopted MCDM technique.

Chapter Five: Application of the Proposed Methodology. This chapter presents and discusses the results of the proposed usability evaluation methodology for selecting OSS. Further, this chapter demonstrates how the proposed methodology's results solve the problems outlined in the problem statements. The results of the validation and evaluation process are also presented.

Chapter Six: Conclusion and Future Work. This chapter provides the study's conclusion and is followed by the highlights, the summary of research contributions, the limitations, and a discussion of future work.

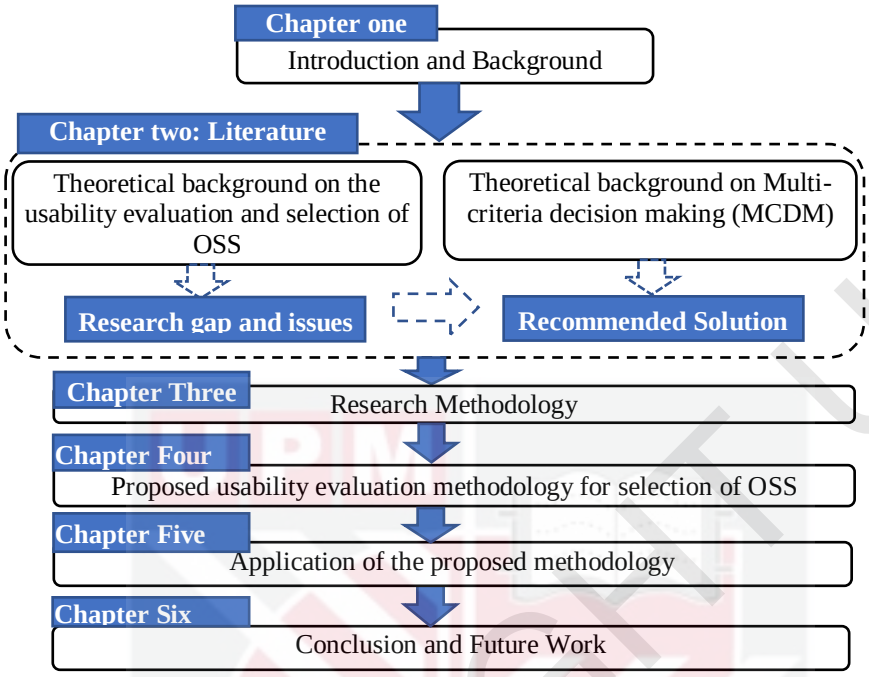

Figure 1.3 : Thesis structure

1.9 Summary

This chapter presents the background of the study. Specifically, it describes the concept of OSS and usability and the criteria that affect the usability evaluation process. The most vital point of this study's background is that usability is measured relative to particular users and tasks. Different users might measure the same system as having different usability characteristics when the system is used for different tasks. This chapter also illustrates the inappropriate selection of an OSS and how it can adversely affect an organisation's legal accountability and cause financial costs if the system fails to meet expectations. Following this are detailed explanations of the problem statement, the research objectives and scope, and the study's significance.

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LIST OF PUBLICATIONS

Dawood, K. A., Sharif, K. Y., Ghani, A. A., Zulzalil, H., Zaidan, A. A., & Zaidan, B. B. (2021a, February 28, 2021). Novel Multi-Perspective Usability Evaluation Framework for Selection of Open Source Software Based on BWM and Group VIKOR Techniques. *International Journal of Information Technology & Decision Making, 20*. https://doi.org/https:10.1142/S0219622021500139

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