A SELECTION FRAMEWORK FOR SOFTWARE PROGRAMMER APPLICANTS BASED ON MULTI- CRITERIA ANALYSIS

FAYIZ MOHAD SAID HAMED MOMANI

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

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DEDICATION

This dissertation is lovingly dedicated to my great beloved parents.

ABSTRACT

This research aimed to propose a framework based on the multi-criteria analysis to aid decision-makers in selecting suitable software programmer applicants. In this study, an experiment was conducted on the basis of several stages. First, decision matrix was proposed for selecting suitable programming applicants based on multi-measurement criteria (structured programming, object-oriented programming, data structure, database system, and courseware engineering), with each criterion comprising two sub-criteria (GPA and Soft skills). In addition, a number of alternatives were generated based on the intersection of the criteria of the applicants. Then, the proposed decision matrix was developed by distributing the courses based on the Software Engineering Body of Knowledge (SWEBOK) standard and expert opinions. Subsequently, the ranking of the applicants was performed by the developed decision matrix using Multi-Criteria Decision Making (MCDM) techniques, namely the integrated Analytic Hierarchy Process (AHP), to weight the multi-measurement criteria, and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was used to rank the alternatives. Data consisting of five main courses as the required criteria were collected from 60 software engineering students, who had graduated from Universiti Pendidikan Sultan Idris (UPSI) in 2016. The research findings showed that the integration of Multi-Layer AHP and Group-TOPSIS was effective in solving the problems associated with the selection of applicants, as evidenced by the systematic ranking of the 60 students. In conclusion, the internal and external aggregations of Group-TOPSIS used in different contexts were able to generate the results of students ranking that were similar. Furthermore, the validated ranking results showed four groups of students have been equally and systematically ranked. The implication of the study is that the programmer could use such a novel framework to improve the quality of software and to reduce the time and cost in the selection process of applicants.

KERANGKA PEMILIHAN PERMOHONAN CALON PENGATURCARA BERDASARKAN ANALISIS PELBAGAI KRITERIA

ABSTRAK

Kajian ini bertujuan untuk menghasilkan satu rangka kerja berdasarkan analisis pelbagai kriteria bagi membantu pembuat keputusan dalam memilih pemohon jawatan pengatur cara perisian yang terbaik. Dalam kajian ini, eksperimen dijalankan berdasarkan beberapa peringkat. Pertama, satu matriks keputusan dicadangkan untuk memilih pemohon terbaik berdasarkan kriteria pelbagai pengukuran (pengaturcaraan berstruktur, pengaturcaraan berorientasikan objek, struktur data, sistem pangkalan data, dan kejuruteraan perisian kursus) di mana setiap kriteria mempunyai dua sub-kriteria (GPA dan kemahiran insaniah). Tambahan pula, beberapa alternatif dijana melalui persilangan kriteria pemohon. Kemudian, matriks yang dicadangkan dibina dengan mengagihkan kursus-kursus berdasarkan standard Badan Ilmu Kejuruteraan Perisian (SWEBOK) dan pendapat pakar. Seterusnya, penentuan kedudukan pemohon berdasarkan matriks keputusan dilaksanakan dengan teknik Membuat Keputusan Pelbagai Kriteria (MCDM), iaitu Proses Hierarki Analitik (AHP), untuk menentukan pemberatan kriteria pelbagai pengukuran, dan Teknik bagi Prestasi Susunan melalui Persamaan untuk Penyelesaian Ideal (TOPSIS) digunakan untuk menentukan kedudukan alternatif berkenaan. Data yang terdiri dari lima kursus utama diperoleh daripada 60 pelajar kejuruteraan perisian yang telah tamat pengajian di Universiti Pendidikan Sultan Idris (UPSI) pada tahun 2016. Dapatan kajian menunjukkan pengintegrasian Kriteria-Pelbagai AHP dan TOPSIS-Kumpulan adalah berkesan dalam menyelesaikan masalah pemilihan pemohon, seperti yang dibuktikan melalui penentuan kedudukan 60 pelajar yang sistematik. Kesimpulannya, TOPSIS-Kumpulan yang digunakan dalam konteks berbeza berdasarkan agregat dalaman dan luaran menunjukkan hasil dapatan yang sama. Selanjutnya, dapatan kedudukan telah disahkan secara objektif membahagikan para peserta kepada empat kumpulan yang seimbang secara sistematik. Implikasinga, programmer dapat menggunakan rangka kerja pemilihan ini untuk meningkatkan kualiti perisian dan mengurangkan masa dan kos dalam proses pemilihan pemohon.

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LIST OF ABBREVIATIONS

MCDM	Multi criteria decision making
DM	Decision Matrix
ICT	Information Communication Technology
DSS	Decision Support System
AHP	Analytic Hierarchy Process
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
EM	Evaluation matrix
MEW	Multiplicative Exponential Weighting
WPM	Weighted Product Method
WSM	Weighted Sum Model
SAW	Simple Additive Weighting
HAW	Hierarchical Adaptive Weighting
ANP	Analytic network process
MAUT	Multi attribute utility theory
GPA	Grade Point Average
SS	Soft Skills
DAE	Data Envelopment Analysis
SWEBOK	Software Engineering Body of Knowledge
WOS	Web of Science
SDLC	Software Development Life Cycle
DMs	Decision Makers
IT	Information Technology
ES	Entrepreneurial Skills
SEVOCSB	Software Engineering Vocabulary
V&V	Verification and Validation
GIS	Geographical Information System
C	Criteria

A	Alternative
NIS	Negative Ideal Solution
PIS	Positive Ideal Solution
UPSI	Universiti Pendidikan Sultan Idris

APPENDICES LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces the research background, problem statement, research objectives, research questions and significance of the study. The scope is also presented and explained, as well as thesis organisation is sufficiently highlighted. Section 1.2 presents a brief background of the research components. Section 1.3 identifies and introduces the problem statement, on which the research direction is based. Section 1.4 follows with a description of the research objectives. Section 1.5 presents the research questions, and Section 1.6 describes the connection between the objectives and questions. Section 1.7 discusses the significance of the study. Section 1.8 elucidates the scope of the study. Section 1.9 briefly outlines the main structure of the thesis. Finally, Section 1.10 summarises this chapter.

1.2 Background of the Study

Educational evaluation and selection have been increasingly enhanced recently. The evaluation of student performance has become a necessary and significant criterion in higher education assessment. Nowadays, higher education committees consider the quality of higher education from the perspectives of student performance improvement, and these committees give considerable attention to student learning outcomes based on evaluation dimensions (Zhang & Yang, 2014).

The most important factor in the process of teaching–learning environment is assessment, which is at the centre of the learning process. Assessment assists education professionals in presenting the progress of students and accomplishments and in discovering new learning trends. Furthermore, educators can also obtain feedback from the assessment process in different courses, such as financial , medical…etc (Hamidi, Shaffiei, Sarif, & Ashar, 2013).up to date ,information technology (IT) has been considered as very challenging because it is an important field and has many related areas; programmers are considered the most important personnel in the IT field because he\she in an important position in information technology (Puthal, Sahoo, Mishra, & Swain, 2015).

Programmers are responsible in translating “a mental plan into one that is compatible with the computer” (B. A. Myers et al., 2016). In other words, programming comprises the coding of a plan into a language that can be read by a computer. The plan is then translated by the computer into program with functions that are comprehensible and usable by users depending on what is seen by the users on the screen.

The tasks and jobs of programmers are to work in many fields, including IT departments, and in large software companies, small service corporations and all sizes of governments units; their jobs/tasks is to work varies widely in order to write programmes that are related to targeted area (Chheda, Carver, & Ashok, 2016). For example, programmers can implement any program that is related to other fields, such as financial, accounting, medical science and other science (Gilal et al., 2017).

Programmers are the most important employees in computer companies because they are responsible in creating functional programmes on the basis of the requirements determined primarily by system analysts and senior programmers (Chheda et al., 2016). The process that comes after design completion is to transform this design into a logical series of instructions; these instructions should be understandable by a computer, and the computer should be capable to follow (Paudel, 2016). When the best programmer is selected, the productivity of a company will increase.

In the current situation, most of employees are not in the right position because most of companies use the traditional way, which is the interview, in the hiring system (Harper, 2015). In other words, the impact of a two-hour interview with an applicant will not lead to hiring the right applicant in the right position. For example, if a company hires the right applicant, then the company will make a profit and improve its productivity. On the contrary, if the company hires a wrong applicant, then the company will break its business. An ideal way to select the best applicant is to hire him/her using long-term data by two perspectives: grade point average (GPA) and soft skills (Kianto, Vanhala, & Heilmann, 2016).

Selecting the best programmer by his/her long-term data will lead to hiring the best applicant in the right position; the main idea of using the long-term data from two perspectives (GPA and soft skills) is to determine whether the programmer applicant is in the right position or not, because the programmer position is in the middle of the designer and tester positions (Kianto et al., 2016). Accordingly, the programmer must have good soft skills, such as communication skills and team work, because he/she will connect with the designer and maintainer to understand the design and translate it to codes to acquire functional programmes and connect with the maintainer for any development or maintenance issues (Kianto et al., 2016).worded differently, the programmer must have good communication skills or teamwork skills because he/she will always take instructions/notes and translate the design and maintenance to functional programmes. If he/she does not have soft skills, then the productivity of the company will decrease because the company hired the wrong applicant.

The best one who can give the result of soft skills is the lecturer who taught the programmer applicants in undergraduate programming courses (Gibb, 2014) because the lecturer can assess the students' skills whilst he/she was teaching the students. Because the teacher was the person who gave the lessons to the students during their studies in undergraduate, and he/she can assess students by observing their behaviours whilst dealing between students with others (Hurrell, 2016), that's lead , this study is needed to select the best programmer and place him/her in the right position by using the long-term data to improve the productivity in information technology companies.

1.3 Problem Statement

Multi-criteria attributes, including GPA and soft skills, for programming courses as integrated platforms for selecting software programmer applicants have not yet been implemented. Selecting the best applicant (programmer) from competing applicants is a complex decision-making process, which often requires a comprehensive evaluation of the applicants' performance (Ingoley & Bakal, 2013a; Mahboob, Irfan, & Karamat, 2016; Veltri, Kaakinen, Shillam, Arwood, & Bell, 2016). A multi-criterion should be simultaneously considered in order to select the qualified and the best programmer. To select a subset of alternatives considering not only the performance of the alternatives evaluated on multiple criteria but also the performance of applicants as a whole must be considered; in this task, balance over alternatives on specific attributes is required by decision makers (DMs) (J. A. Myers et al., 2014).

Many specific issues affect the selection of the best programmer applicant amongst others. Core courses of programming major in software engineering programming represent an important factor in selecting the best programmer applicant. Thus, the selection process with multi-evaluation criteria (core courses) is considered the first issue (Deni, Sudana, & Sasmita, 2013).

A problem emerges when the applicants are selected using several criteria (including GPA and soft skills) (Aggarwal, 2013; Deliktas & Ustun, 2015). Each competing applicant (programmer) has several attributes, which are given different weights by each decision maker. Selecting the suitable applicant is consequently difficult and is considered the second issue.

Data variation also exists amongst the available alternatives that are characterised by multiple attributes (Velasquez & Hester, 2013), and it is generated because all data are from the same scale but have different values. This condition is considered the third issue (Leyva López, 2005). The selection process of the applicants as programming students can be considered a multi-criteria decision-making (MCDM) problem (Roszkowska, 2013). The problem statement configuration is illustrated in Figure 1.1.

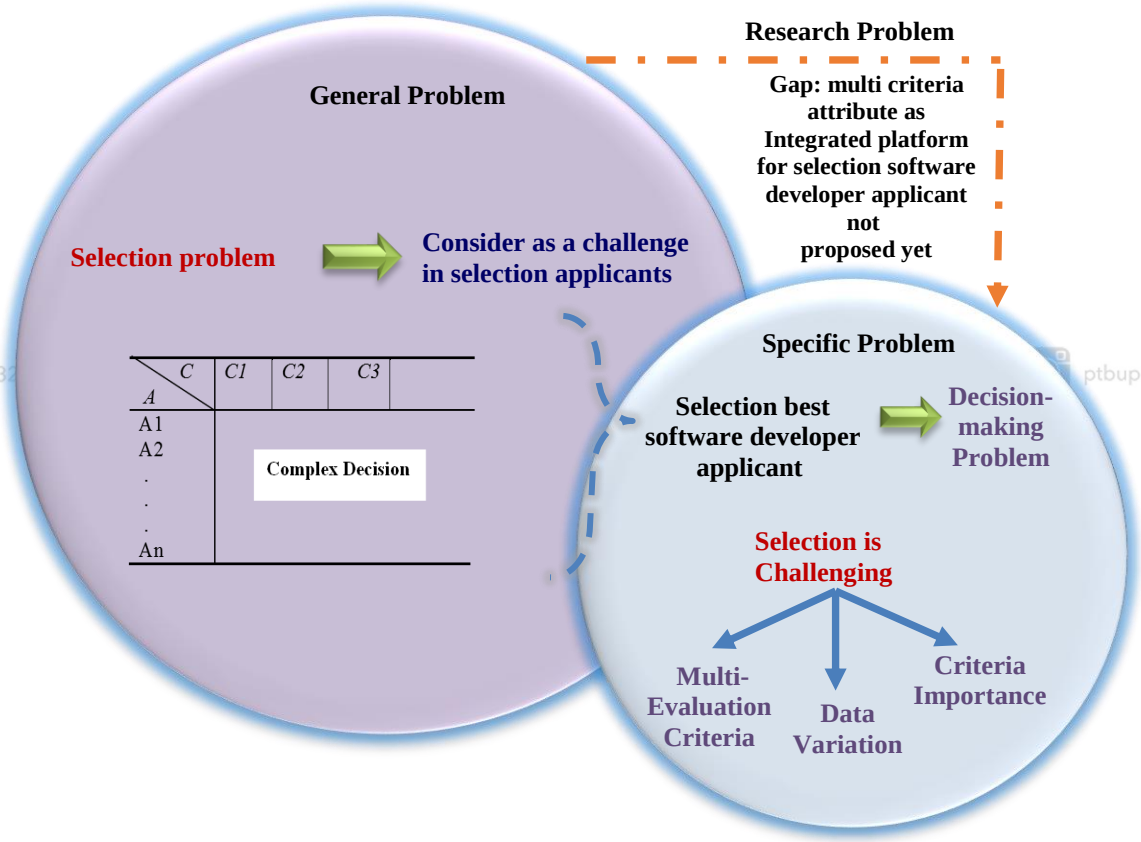

Figure 1.1 Problem statement configuration

Figure 1.1 illustrates the problem statement from three dimensions: the gap, general problem and specific problem, the gap found from the systematic literature and the present situation that no any integrated platform for selecting software programmer applicants has been implemented in previous studies.

In the other hand, the general problem and its found the selection is a complex problem and its consider as a general problem, for the specific problem is divided into three part which are multi-evaluation criteria, criteria importance and data variation.

1.4 Research Objectives

The objectives of this research are presented as follows:

1. To investigate the existing criteria for student evaluation and highlight the weaknesses
2. To propose a decision matrix for software programmer applicants based on software construction-related subjects
3. To develop a selection framework for software programmer applicants based on the proposed decision matrix using multi-criteria analysis
4. To validate the proposed selection framework objectively

1.5 Research Questions

The formulated questions for this research are presented below:

1. Are there any available criteria for selecting software programmer applicants?
2. Is there a need to make a selection framework for software programmer applicants?
3. What are the criteria that have been used to select software programmer applicants?

4. What are the integrated platforms that have been used to select software programmer applicants?
5. Is there any selection framework for software programmer applicants based on multi-criteria analysis used?
6. Is the developed selection framework reliable enough to select software programmer applicants?
7. Is the result of selecting software programmer applicants valid?

1.6 Connections between Research Objectives and Research Questions

Table 1.1 shows the connection between the research objectives and the research questions. The first, second and fourth objectives include two questions, and the third objective comprises only one question. The objectives and questions are elucidated in Table 1.1.

Table1.1

Connections between Research Objectives and Research Questions

	Research Objectives	Research Questions	Problem Statement Mapping	
			Specific	General
1	To investigate the existing criteria for student evaluation and highlight the weaknesses	Are there any available criteria for selecting software programmer applicants? Is there a need to make a selection framework for software programmer applicants?	1- Multi - Evaluation Criteria	Selection of the best software programmer applicant
2	To propose a decision matrix for software programmer applicant based on software construction-related subjects	What are the criteria that have been used to select software programmer applicants? What are the integrated platforms that have been used to select software programmer applicants?		

(continue)

Table 1.1 *(continued)*

	Research Objectives	Research Questions	Problem Statement Mapping	
			Specific	General
3	To develop a selection framework for software programmer applicants based on the proposed decision matrix using multi-criteria analysis	Is there any selection framework for software programmer applicants based on multi-criteria analysis used?	2- Data Variation 3- Criteria Importance	Selection of the best software programmer applicant
4	To validate the proposed selection framework objectively	Is the developed selection framework reliable enough to select software programmer applicants?		
		Is the result of selecting software programmer applicants valid?		

1.7 Significance of the Study

The significance of this study is to help software companies to select the best programmer amongst applicants that's help the companies to create applications either (application software, system software and computer programming tools) in high quality and high performance. Accordingly, software development companies prefer skilled candidates to save costs (Burke, Bailey, Lyon, & Greeen, 2018), and the benefits of this study are listed as follows:

- Application software: Companies which offer application software are always looking for programmers to develop this type of software. Thus, this study helps them select the best programmer for developing the application software.

• System software: A programmer that develops system software should be intelligent and creative.

This type of software is used in networks; therefore, the applicants should have sufficient skills to do the work. This study provides an easy way for the companies to select the appropriate person for developing the system software.

• Computer-programming tools: This study contributes in the hardware area as well. Developer applicant should have hardware coding skills and knows how to combining source codes and libraries into an executable RAM. However, companies that offer this type of tools are looking for the best programmer to select in order to save money.

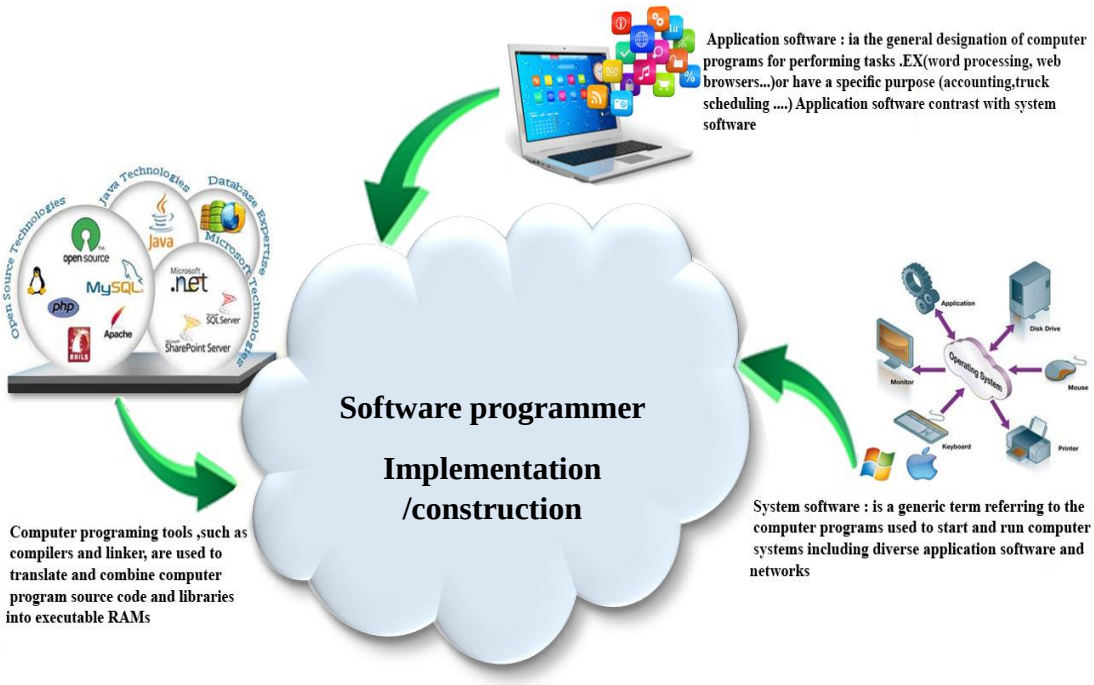

Figure 1.2 Benefits of the study

Figure 1.2 illustrates the benefits of this study which will helping companies to select the best software programmer applicant to improve the productivity and performance of the company from three domains, these domains are namely: application software, system software and computer-programming tools.

1.8 Scope of the Study

The scope of the study comes from three dimensions. The first dimension is the research method, which includes a case study and experiment. The research is conducted in Universiti Pendidikan Sultan Idris (UPSI) Malaysia, in order to construct the commonly used criteria in the selection of software programmer students following their graduation from their education institution (University). The data that used are the programming-related subjects of AC10 programme that are evaluated by the lecturers that teach their subjects during students' studies in performance and soft skills. regarding to experimental part, the proposed selection framework is developed on the basis of two perspectives. which are human opinion and mathematical model (Nilsson, Nordström, & Öhman, 2016). The second dimension is the research type, which is a framework type, due to the proposed selection framework for software programmer applicants amongst other software development life cycle (SDLC) levels.

The third dimension refers to the research domains, namely, software engineering, expert system and decision-support system. Regarding to the software engineering domain, the software programmer students are the case study and this domain is considered a one of the software engineering major.

While, the expert system domain is mentioned because the proposed framework is developed on the basis of MCDM techniques. Domains are depicted in Figure 1.3.

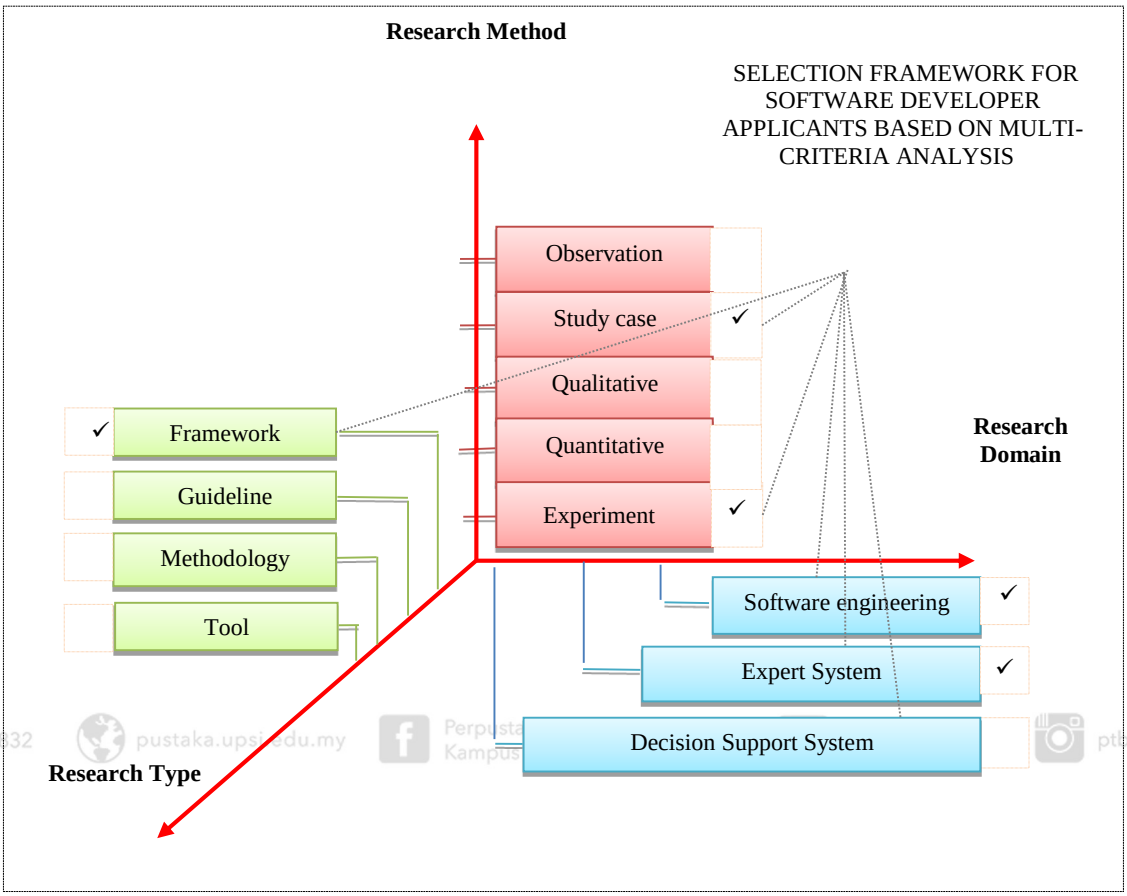

Figure 1.3 Research scope

1.9 Thesis Organisation

This thesis follows the academic writing structure to provide clear visions of the research and to achieve the research objectives efficiently, which maximise the performance of research contributions. The chapter structure of this thesis is detailed as follows:

Chapter 1: Introduction

This chapter presents the necessary general information and background of the research. The problem statement, questions and objectives of this study are defined. The research scope and approaches are clarified to ensure the valuable contributions of the results.

Chapter 2: Literature Review

This chapter reviews the literature and the related models to develop the research model based on a solid theoretical background.

Chapter 3: Research Methodology

This chapter draws the methodology of the research. The main focus of this chapter is on the approach that the research follows to answer the questions of this research. The methodology phases and data collection and data analysis are drawn.

Chapter 4: Results and Discussion

This chapter presents the results based on the proposed method in six sections, each with its own aims. These sections show the results of the data presentation, the alignment processes used and the weighting and ranking processes.

Chapter 5: Conclusion and Future Work

This chapter presents the conclusion and contributions. Areas to be pursued in the future work are also suggested.

1.10 Summary

This chapter describes the background of this study, which includes educational evaluation, followed by the most important factor, which is the assessment. therefore, the background of study describes the programming process and how to convert a mental plan into one that is compatible with the computers are explained. as long as , the background of study also describe the programmer job followed by the importance of programming employee ,the last section in background of study is the current situation which include the situations of employees are not in the right position as well as , Using long term data is determined to be the best way to assist students, and the best one who can assist the student is their lecturer who teach these students. The problem statement is provided, and the objectives, questions and significance of this study are elucidated. The study's scope as well as organization are sufficiently highlighted.