A DECISION MATRIX FOR OPTIMIZE THE ABILITY OF SOFTWARE ENGINEERING STUDENTS

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SULTAN IDRIS EDUCATION UNIVERSITY

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A DECISION MATRIX FOR OPTIMIZE THE ABILITY OF SOFTWARE ENGINEERING STUDENTS

OMAR MOHAMMAD RAJI ALZGHOUL

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DEDICATION

This dissertation is lovingly dedicated to my great beloved parents, especially to my father, who passed away. My deepest gratitude and prayers go to him for his efforts done every source he had when he was alive to support me throughout my life and my education. I miss him every day, may his soul rest in peace.

ABSTRACT

This research aimed to propose a decision matrix based on multi-criteria analysis to aid decision-makers in optimizing the ability of software engineering students. In this study, an experiment was conducted on the basis of several stages. First, decision matrix was constructed to rank the ability of software engineering students based on multi-measurement criteria (Grade Point Average (GPA) and soft skills) and Software Development Life Cycle (SDLC) process levels as alternatives. Then, the constructed decision matrix was adapted by distributing the courses of SDLC process levels based on Software Engineering Body of Knowledge (SWEBOK) standard and expert opinions using Multi-Criteria Decision Making (MCDM) techniques based on Analytic Hierarchy Process (AHP) to weight the alternatives. Next, the ability of students was ranked based on the adapted decision matrix using the integrated AHP to weight the multi-measurement criteria, and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) was used to rank the alternatives. The data consisted of the grades of courses and soft skills of 60 students of Universiti Pendidikan Sultan Idris (UPSI), who had graduated in 2016. The results of this study showed the integration of AHP and TOPSIS was effective in ranking the ability of students based on their scores of strengths, indicating that 14 (23%) of the students were requirements collectors, 13 (22%) were designers, 5 (8%) were programmers, 13 (22%) were testers, and 15 (25%) were maintenance personnel. In conclusion, significant differences were observed between the groups' scores for each level of SDLC, indicating that the ranking results were identical for all levels. The implication of this study is that lecturers gain the benefits by identify the strengths and weaknesses of their students such that they can provide better supervision. Likewise, benefits to students by determine their actual ability, allowing them to take the necessary measures to improve their learning performance.

MATRIKS KEPUTUSAN BAGI MENGOPTIMA KEBOLEHAN PELAJAR KEJURUTERAAN PERISIAN

ABSTRAK

Kajian ini bertujuan untuk mencadangkan matriks keputusan berdasarkan analisis pelbagai kriteria bagi membantu pembuat keputusan dalam mengoptimakan kebolehan pelajar kejuruteraan perisian. Dalam kajian ini, eksperimen dijalankan berdasarkan beberapa peringkat. Pertama, satu matriks keputusan dibangunkan untuk menentukan kedudukan kebolehan pelajar kejuruteraan perisian berdasarkan kriteria pelbagai pengukuran (Purata Nilai Gred (GPA) dan kemahiran insaniah) dan tahap proses Kitar Hayat Pembangunan Sistem sebagai alternatif. Kemudian, matriks keputusan yang telah dibina disesuaikan melalui pengagihan kursus-kursus mengikut tahap proses SDLC berdasarkan standard Badan Ilmu Kejuruteraan Perisian (SWEBOK) dan pendapat pakar dengan menggunakan teknik Multi-Criteria Decision Making (MCDM) berdasarkan Proses Hierarki Analitik (AHP) bagi menentukan pemberatan setiap alternatif. Seterusnya, kebolehan pelajar ditentukan kedudukannya berdasarkan matrik keputusan berkenaan dengan menggunakan AHP yang terpadu bagi menentukan pemberatan kriteria pelbagai pengukuran, dan Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) digunakan untuk menentukan kedudukan alternatif-alternatif. Data terdiri dari gred-gred kursus dan kemahiran insaniah yang diperoleh daripada 60 orang pelajar kejuruteraan perisian yang telah tamat pengajian di Universiti Pendidikan Sultan Idris (UPSI) pada tahun 2016. Dapatan kajian menunjukkan pengintegrasian AHP dan TOPSIS adalah berkesan dalam menentukan kedudukan kebolehan pelajar berdasarkan skor kekuatan mereka di mana 14 (23%) pelajar adalah merupakan pengumpul keperluan, 13 (22%) adalah pereka, 5 (8%) adalah pengatur cara, 13 (22%) adalah penguji, dan 15 (25%) adalah penyelenggara. Kesimpulannya, perbezaan signifikan dikesan di antara skor setiap kumpulan bagi setiap tahap SDLC yang menunjukkan bahawa dapatan kedudukan adalah sama bagi semua tahap yang terlibat. Implikasinga, kajian ini akan mendatangkan kebaikan kepada para pensyarah untuk mengenal pasti kekuatan dan kelemahan pelajar mereka agar mereka dapat menyediakan kawal selia yang lebih baik lagi. Begitu juga, para pelajar dapat menentukan kebolehan sebenar mereka agar langkah-langkah yang sesuai dapat diambil untuk mempertingkat prestasi pembelajaran mereka.

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
CS	Communication Skills
CTPS	Critical Thinking and Problem-Solving Skills
DAE	Data Envelopment Analysis
DM	Decision Making
DSS	Decision Support System
ELECTRE	Elimination EtChoix Traduisant la REalite´
EM	Evaluation matrix
ES	Entrepreneurial Skills
FAHP	Fuzzy Analytic Hierarchy Process
FMCDM	Fuzzy Multi-criteria decision making
FTOPSIS	Fuzzy Technique for Order Preference by Similarity to Ideal Solution
FYP	Final year project
GDM	Group Decision Making
GPA	Grade Point Average
HAW	Hierarchical Adaptive Weighting
ICT	Information Communication Technology
IS	Information System
LLIS	Lifelong Learning and Information Management Skills

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LS	Leadership skills
MAUT	Multi-attribute utility theory
MCDM	Multi Criteria Decision Making
MEW	Multiplicative Exponential Weighting
MLAHP	Multi-layer Analytic Hierarchy Process
MOHE	Ministry of higher education
MPES	Moral and Professional Ethics
PIS	Positive Ideal Solution
PLO	Programme learning outcome
PM	Project management
RE	Requirement engineer
SAW	Simple Additive Weighting
SJT	Situational Judgment Test
SLO	Student learning outcome
SS	Soft skills
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
TS	Team-Working Skills
UPSI	Universiti Pendidikan Sultan Idris
WPM	Weighted Product Method
WSM	Weighted Sum Model

APPENDICES LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents the direction of the study and is divided as follows: Section 1.2 analyses and describes the background of the study in detail. Section 1.3 Terminology Sequences for research direction presents the sequences of the problem background. Section 1.4 Statement of the Problem identifies and introduces the direction of the research and discusses the gaps, main challenges and issues in detail. Section 1.5 presents the questions that should be answered in this study. Section 1.6 lists the objectives of this study based on the previous section. Section 1.7 Connections Amongst Research Objectives and Research Questions shows the question and answer for each objective.

Section 1.8 explains the research method, type and domain. Section 1.9 discusses the benefits of this study to students, teachers and organisations. Section 1.10 Research Organisation describes the chapters in this section. Section 1.11 summarises the chapter.

1.2 Research Background

The practice of evaluation and assessment has been increasing, and related issues faced by researchers could have resulted from a lack of communication (Kron et al., 2017) and sample size (San Miguel & Rogan, 2015), (Walia & Marks-Maran, 2014). Challenges in problem solving are significant but might not provide real outcomes for evaluation (Chandrasekaran, Long, & Joordens, 2015). Other concerns include challenges with data (O'Brocta & Swigart, 2013), evaluation types or tools (Molins-Ruano, Rodriguez, Atrio, & Sacha, 2016) and criteria (Bennett, 2016; Fauzi, 2013)

The evaluation of student performance has become a necessary and significant criterion in higher education assessment (Erkkilä, 2013). Nowadays, higher education committees, which consider the quality of higher education from the perspective of student performance improvement, give considerable attention to student learning outcomes based on evaluation dimensions (Zhang & Yang, 2014).

The most important factor in the process of the teaching–learning environment is assessment, which is at the centre of the learning process (Rowntree, 2015). Assessment assists education professionals in presenting the progress and accomplishments of students and in discovering new learning trends.

Furthermore, educators can obtain feedback from the assessment process (Hamidi, Shaffiei, Sarif, & Ashar, 2013).

Assigning projects to students as part of a course is common practice in universities with different criteria and specific conditions (Pan, Chu, Han, & Huang, 2009). Most students tend to choose or select an easy project so they can graduate on time. Thus, an 'easy' and 'doable' project becomes a favourite, as confirmed by lecturers (Wook et al., 2012). In this case the ability of students must ranked to capture the strength and weaknesses of each student. Criteria for ranking the ability of students are considered a multi-criteria learning outcome.

A learning outcome is a measurement of student performance. Two criteria are used to measure the learning outcome and are called multi-criteria learning outcome, which measure the ability of students. According to (Pan et al., 2009), grade point average (GPA) is the main criterion for evaluating student performance and is used to ranking the ability of students. Soft skills are the main criteria in evaluating the students (F. Ahmad, Ghazali, Madi, Rose, & Safei, 2012). (Ito, Naoe, Imazawa, & Matsushita, 2015) confirmed that students must improve their innovative skills because they are important in innovation

Ranking the ability of the students can reveal the true potential in applying their skills and knowledge learned while pursuing their bachelor's degree (Ku & Goh, 2010). The FYP aims to provide students with experience in practical project work and measure their skill and ability in this field.

The FYP trains students in performing a relatively large task on their own (Abdüsselam). Through the FYP, students can integrate all the knowledge and skills they developed throughout their studies to complete a project that is proposed or discussed between students and their supervisors (Wook et al., 2012). The main aim of FYP is to prepare the students for the research field.

The quality of the FYP is the main concern, especially in IT and software engineering. According to (Roger & Cobos, 2009), IT and engineering FYP should develop high-quality work that is relevant to the needs of research and industries. However, the quality of the prototypes developed by the students in computer fields has decreased nowadays. This phenomenon is not an isolated case in computing departments and has also been perceived in other universities in the United Kingdom (Bouki, 2007).

Learning outcome criteria (soft skills, performance [GPA]) that affect the quality of FYP are ready and available for use at any time (Misran, Mokri, Husain, & Zaki, 2011). Datasets such as grades and soft skills for every course obtained by the student can be used to rank their ability, possibly affecting the quality of FYP in the near future (Sharef et al., 2013).

1.3 Terminology Sequences for Research Direction

One of the main problems faced by students is the selection of the FYP area. The project selection, which depends on the selection technique applied by the department, is up to the student (Sharef et al., 2013).

In the current scenario, if a disagreement occurs between the supervisor and the student, then in most cases, students can follow the path they prefer and be responsible for the final output (M. Hasan, Sahari, & Anuar, 2009). An odd thing then happens here. Students are unwilling to show initiative in the selection and the progress of their FYP. They mostly have the attitude they display during taught courses ('tell me what to do/read/learn') instead of being independent. However, students are not qualified to work independently. Sometimes, when the project has run halfway, students seem lost and unable to proceed, so ranking software engineering student ability to determine in which level he/she has weakness is an important issue . For instance, some students have weaknesses in programming issues, and at the same time, they should be a developer to complete their FYP, here the supervisor will know that certain student have weakness in programming so he/she can train them. Same case can be happen in the same SDLC, for example to design and other SDLC levels (Jusoh, Husni, Ismail, Omar, & Abdullah, 2017).

Experience in developing the FYP can be stimulating and inspiring for students and their supervisors. However, the process of the FYP may sometimes be a discouraging and disappointing period in IT or software engineering studies, and students who become stuck at one stage do not find sufficient support (Roger & Cobos, 2009). The main problem occurs because software engineering students have some weaknesses in some parts and the supervisor couldn't recognize that. The grades and the soft skills students gained might affect the area of interest they are good at. Student experience and background may influence the quality of the FYP (Berndtsson, Hansson, Olsson, & Lundell, 2002).

The computer science, IT and software engineering departments offer the FYP course for IT and software engineering students. It is a compulsory subject, and students are expected to apply and integrate the knowledge learned through various courses to complete the six credit hours' project with a project report. '

In the current situation, students are expected to work separately based on the project title agreed upon by the student and the assigned supervisor, who is a lecturer within the department. Topics can be suggested by either the student or the supervisor, and both should agree on the topic (Arrebola et al., 2015). However, the department observes that an increasing number of students fail to complete their FYP within the allocated time (R. Wang et al., 2014). This condition occurs because software engineering students have different abilities.

The students in a computer facility take the software engineering program, and software development life cycle (SDLC) is considered the umbrella of these programs. Software engineering educators do not have any tools that aid them in designing and evaluating their educational programs. However, they have standards, such as software engineering body of knowledge (SWEBOK) (Kajko-Mattsson, 2012), which was designed for categorising and labelling the body of knowledge of software engineering (Bourque et al., 2002).

SWEBOK is 'an important milestone in the history of the software engineering discipline'. The main question that might be verified in the face of such knowledge definition is: Does this body of knowledge cover my particular level (Guelfi, Capozucca, & Ries, 2016).

However, software engineering departments use the term SWEBOK as an 'international standard ISO/IEC TR 19759:2005, specifying a guide to the generally accepted Software Engineering Body of Knowledge'.

Members of the industry cooperated with several professional bodies to create the Guide to the SWEBOK (SWEBOK Guide), which was published by the IEEE Computer Society (IEEE) (Calero & Piattini, 2015).

To provide a precise idea on what software engineering is, the important standardisation effort made by ISO and IEEE during the last years delivered the SWEBOK (Guelfi, Capozucca, & Ries, 2017). This body of knowledge has 15 knowledge areas (KA) decomposed into topics and sub-topics. The first five categories relate to the SDLC (Bezerra, da Silva, Santana, Magalhaes, & Santos, 2015).

SDLC is a procedure followed for a software project within software organisations. It consists of a detailed plan that describes how to collect the requirements and design, develop, maintain, replace and alter or enhance specific software (Radack, 2009). The life cycle defines a method for improving the quality of software and the overall processes. SDLC is a term used in information systems, systems engineering and software engineering to define a process for planning, creating, testing and deploying systems (Kissel et al., 2008).

An SDLC is collected from clearly defined and distinct work phases that are used by systems engineers and systems developers to plan, design, develop, test and deliver information systems (Leau, Loo, Tham, & Tan, 2012).

Similar to anything that is manufactured on an assembly line, SDLC aims to distribute tasks to appropriate persons to supply high-quality systems based on customer requirements by meeting the scheduled time frames and cost estimates (Demir, 2015).

This research identifies further details on elements or factors that affect to the ability of the software engineering students from the available datasets based on the perception of lecturers within the department. Multi-criteria analysis is used to rank the ability of the student. In conclusion, our study contributes to the research field by addressing the shortcomings of similar studies.

1.4 Problem Statement

In order to figure out the strength and weaknesses for software engineering students in SDLC processes levels. Up to our knowledge, no decision matrix exists for ranking and optimizing the ability of software engineering students on the basis of an integrated platform between multi-criteria learning and the SDLC as a decision matrix (DM); hence, this issue is considered in gap analysis for this research. The multi-criteria attribute as an integrated platform for ranking the ability of software engineering students has not been implemented yet. Hence, classifying software engineering students according to the SDLC stages based on their ability is the main challenge (Veltri, Kaakinen, Shillam, Arwood, & Bell, 2016) (Mahboob, Irfan, & Karamat, 2016) (Ingoley & Bakal, 2013a). Optimising the ability of the students is a ranking problem. In addition, student evaluation and assessment is a challenge in the computer field and other fields (Abdeljaber & Ahmad, 2017). Finding a suitable method for evaluating students is a critical factor in the education domain (Myers et al., 2014).

To describe the specific problems in terms of issues for ranking the ability for software engineering students, four issues are described as specific problems.

The process of ranking the ability of students with multi-attributes (GPA and soft skills) with respect to the proper weight assigned for each attribute is a multi-attribute DM; this is the first issue (Deni, Sudana, & Sasmita, 2013). However, the problem appears when students are evaluated using several criteria (performance, soft skills). Each student has several criteria for evaluation, and each decision maker has different importance (weights) for these criteria; this is the second issue (Roszkowska, 2013). The data vary from one student to another; for example, when evaluating the students, student (A) may receive a high GPA mark but receive a low mark in soft skills. By contrast, student (B) may receive a low GPA mark but receive a high mark in soft skills; this scenario is considered a data variation, which is the third issue (Leyva López, 2005). Furthermore, to classify the students to the SDLC, the alternative members should be weighed; this is the fourth issue (Roszkowska, 2013). Figure 1.1 illustrates the general problem and specific problem.

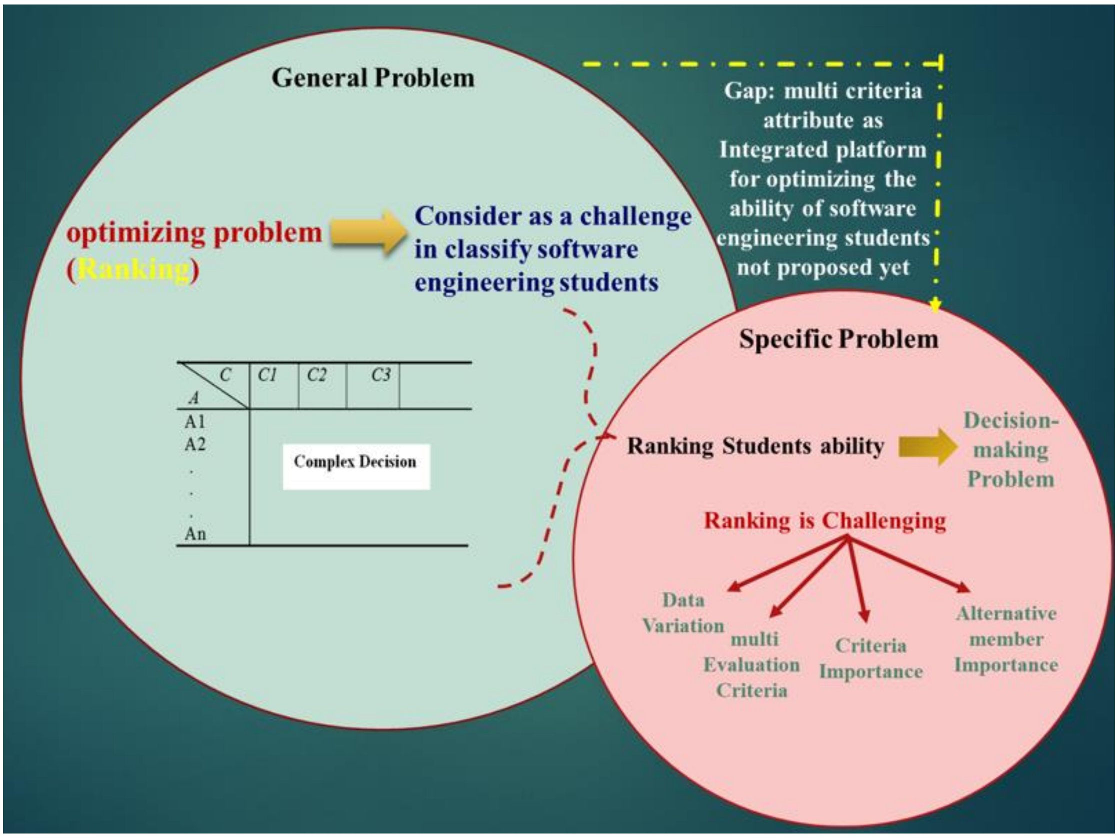

Figure 1. 1 Research Problem

Selecting the suitable SDLC levels to use is difficult. The ranking of SDLC levels for each student (in particular, software requirements, software design, software development, software maintenance and software testing) is a multi-criteria decision making (MCDM)/multi-attribute decision making (MADM) problem where each SDLC level for each student is an alternative for the decision maker. The MCDM/MADM problem refers to making the first choice or decision amongst the presented alternatives that are characterised by multiple data (A. Zaidan, B. Zaidan, M. Hussain, et al., 2015).

The process of ranking the SDLC level for each student includes considering the criteria and alternatives. Thus, the selection process of the SDLC levels for each student can be considered a multi-criteria decision problem.

1.5 Research Questions

This study should answer the following questions, some of which should be answered in the theoretical part, and the others should be answered in the practical part:

1) What existing studies have been conducted with regard to the criteria for student evaluation?
2) What are the requirements for constructing a decision matrix for student classification?
3) What are the available criteria for ranking student ability?
4) What is the available standard for classifying software engineering courses?
5) Who can make the decision for classifying the courses?
6) What is the suitable technique for developing proposing a decision matrix?
7) Are the results of the decision matrix valid?

1.6 Research Objectives

The research objectives of this study are as follows:

1. To investigate the existing criteria for the student's evaluation and highlight the weaknesses.
2. To identify the decision matrix for ranking the ability of software engineering students, based on multi-measurement criteria and SDLC process levels.
3. To adapt the identified decision matrix by distributing the courses for SDLC process levels using SWEBOK and expertise opinion

4. To rank the ability of software engineering students based on adapted decision matrix using multi-criteria analysis

5. To validate the ranking results for adapted decision matrix objectively.

1.7 The Connections Among Research Objectives, research questions

In this study, research questions should be answered, all of which are answered by the research objective. Each objective is linked to one or two questions, which means the research objective answers the research questions. Table 1.1 presents the link between the research objectives and questions.

Table 1. 1

The Link Between Research Objectives And Research Questions

Research questions	**Research objectives**
1)What existing studies have been conducted with regard to the criteria for student evaluation? 2)What are the requirements for constructing a decision matrix for student classification?	To investigate the existing criteria for the student's evaluation and highlight the weaknesses.
1) What are the available criteria to ranking student ability?	To identify the decision matrix for FYP, based on multi-measurement criteria and SDLC process levels.
1) What is the available standard for classifying the software engineering courses? 2) Who can make the decision for classifying the courses	To adapt the identified decision matrix by distributing the courses for SDLC process levels using SWEBOK and expertise opinion

(Continue)

Table 1.1 *(Continued)*

Research questions	**Research objectives**
1) What is the suitable technique followed to propose the decision matrix?	To rank the ability of software engineering students based on adapted decision matrix using multi-criteria analysis
Are the results of the decision matrix valid?	To validate the ranking results for adapted decision matrix objectively.

The first objective answers two questions, the second objective answers one question, the third objective answers two questions and the fourth and fifth objectives answer one question each

1.8 Research Scope and schema

This study is conducted in Universiti Pendidikan Sultan Idris (UPSI), Malaysia, and aims to improve the process of student evaluation and optimise the ability of each student by ranking the ability. FYP is used to evaluate the fourth year students in the AC10 program at UPSI, Malaysia (graduate students). In addition, this study determines the criteria for classifying the software engineering students to SDLC stages to determine their ability. Figure 1.2 presents the scope of the research.

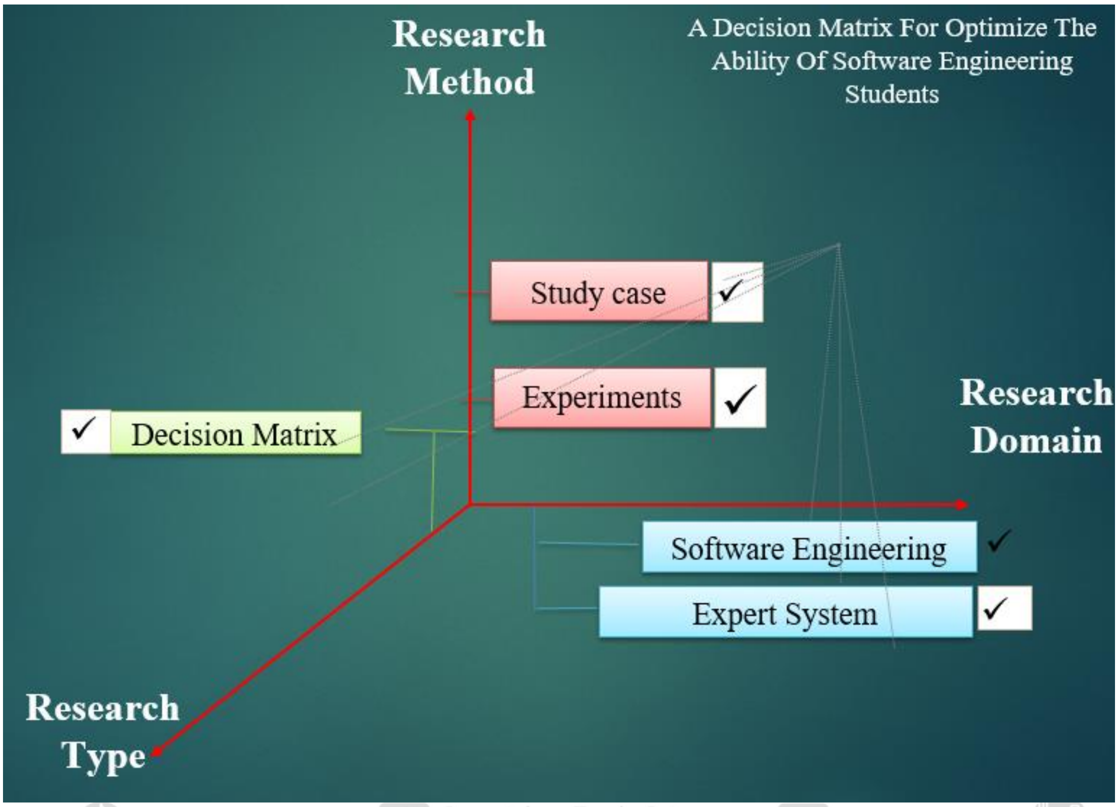

Figure 1. 2 Research Scope

Figure 1.2 shows that the method of our research is a case study and involves ranking the ability of software engineering students, classifying them to SDLC level. It is implemented experimentally through human perspective and mathematical model. The research type is a decision matrix ; a decision matrix is built to help the software engineering students optimise their ability. The research domain consists of two subdomains: software engineering, with software engineering students in UPSI serving as the samples to prove the concept of this study; expert system, that is, this study is conducted in the expert system domain

1.9 Significance of Study

The first of the 10 shifts in the Malaysia Education Blueprint 2015–2025 (MOHE) emphasises the formation of holistic, entrepreneurial and balanced graduates (Lee, 2017). The concept of soft skills is formulated to address graduate employability, which will ensure positive growth for the nation (Adnan, Daud, Alias, & Razali, 2017).

Concerted and dedicated effort is necessary to achieve this goal, especially for a major institution of higher learning. Soft skills address the graduate employability concern (Lowden, Hall, Elliot, & Lewin, 2011). However, the idea of measuring the soft skills is useless if the dataset is not available. Enhancing student performance whilst they are in university is not considered in applying FYP projects. Software engineering is one of the most important fields for the Ministry of Higher Education (MOHE), which focuses on and supports the field with many research grants.

Conducting research should be taught from the university level through the FYP. Hence, the benefits of this study are threefold.

1) Benefits to students

- ranking the ability of students will help them choose the title for their FYP based on their knowledge.
- Students can complete the requirements on time.

2) Benefits to education organisations

- This study provides a way to improve the evaluation process for the students.

- This study can help improve the quality of education.

3) Benefits to lecturers

- Each lecturer will be responsible for the students who are conducting their FYP in his/her field only so he/she can supervise them easily.

1.10 Research Organization

This study is composed of five chapters, which are briefly reviewed as follows.

Chapter 1 provides the research background and problem as well as demonstrates the research objectives and scope.

Chapter 2 is a systematic review protocol for the evaluation of students, followed by a thorough analysis as a literature survey and an overview of FYP.

SWEBOK and SDLC are also reviewed, followed by the criteria used to evaluate the students. The chapter ends with technical analyses of the research problems and highlights suggestions to solve these problems.

Chapter 3 provides a full description of the research methodology, which consists of five phases: preliminary study, identification, preprocessing, development and validation. Each phase corresponds to and addresses one or more research objectives. A detailed description of the proposed method is presented to validate the proposed model.

Chapter 4 presents the results based on the proposed method, validation results of the proposed method. In this chapter, several steps are taken to test the performance of the proposed method in ranking students' ability in an educational environment to overcome the research problems.

Chapter 5 presents the conclusion and contributions. Areas to be pursued in future work are also suggested.

1.11 Chapter Summary

This chapter provides a background of the student evaluation process, FYP and SWEBOK in an education setting. In addition, terminology sequences for research direction are discussed. In the statement of the problem, the evaluation of students is defined as a complex MCDM. The study focuses on improving the process of evaluating the students and classifying them based on their ability.

Research questions and objectives are discussed. The extent and constraints of this study are elaborated. The final part of this chapter presents the general idea of the other chapters of this thesis.