A LECTURER-COMMITTEE ASSIGNMENT PROBLEM USING INTEGER PROGRAMMING MODEL

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Abstrak

Kajian ini memfokuskan masalah agihan jawatankuasa di kalangan pensyarah di Pusat Pengajian Sains Kuantitatif (SQS), Universiti Utara Malaysia (UUM). Di SQS, jawatankuasa dibentuk untuk menyokong pusat pengajian mencapai petunjuk prestasi utama (KPI) UUM. Oleh itu, setiap jawatankuasa memerlukan sebilangan pensyarah untuk mengatur aktiviti dalam spesifikasi tugasan mereka. Pada masa ini, pensyarah diagihkan kepada jawatankuasa secara manual oleh pihak pengurusan SQS. Tiada pendekatan sistematik digunakan bagi mengagihkan pensyarah kepada jawatankuasa. Ini mungkin menyebabkan pensyarah kurang berminat dalam memberikan komitmen. Bagi mengatasi kelemahan tersebut, kajian ini membangunkan model Pengaturcaraan Integer (IP) untuk mengagihkan pensyarah ke jawatankuasa dengan mempertimbangkan pilihan pensyarah dan pihak pengurusan. Model IP ini memaksimumkan jumlah pemberat pilihan pensyarah berdasarkan 20 jawatankuasa yang dicadangkan oleh pihak pengurusan. Pemberat pilihan diperoleh daripada tinjauan ke atas 54 pensyarah. Penyelesaian optimum daripada model IP menghasilkan jumlah pemberat pilihan yang lebih tinggi berbanding amalan semasa dengan kenaikan 19.91%, iaitu menggambarkan penyelesaian yang lebih baik dalam masalah agihan jawatankuasa di kalangan pensyarah di SQS. Model IP yang dibangunkan ini membantu pihak pengurusan dalam mengagihkan pensyarah ke jawatankuasa secara efektif dan sistematik, bagi meningkatkan kepuasan dan komitmen mereka dalam mencapai KPI UUM.

Kata Kunci: Masalah agihan, Pengaturcaraan integer, Penyelesaian optimum

Abstract

This study focuses on the lecturer-committee assignment problem at the School of Quantitative Sciences (SQS), Universiti Utara Malaysia (UUM). In SQS, committees are established to support the school to achieve the UUM key performance indicators (KPIs). Therefore, each committee requires a certain number of lecturers to organize activities within their job specifications. Currently, lecturers are assigned manually to the committees by the SQS management team. There is no systematic approach to assigning the lecturers to the committees. This may cause the lack of interest of the lecturers and their commitment. To overcome the drawbacks, this study develops an Integer Programming (IP) model to assign the lecturers to committees by considering both the lecturers' and management team's preferences. The IP model maximizes the total preference weight of the lecturers based on 20 committees recommended by the management. The preference weight was obtained from a survey conducted to 54 lecturers. The optimal solution of the IP model provides a higher total preference weight compared to the current practice with an increment of 19.91%, which reflects a better solution to the SQS lecturer-committee assignment problem. The developed IP model effectively and systematically assists the management team in assigning lecturers to the committees, which may increase their satisfaction and commitment to achieve the UUM's KPIs.

Keywords: Assignment problem, Integer programming, Optimal solution

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CHAPTER ONE

INTRODUCTION

1.1 Lecturer-Committee Assignment Problem

The lecturer-committee assignment problem is to assign a set of lecturers to a set of committees with the purpose to assign these lecturers in an effective way for which an optimal assignment can be performed in the best possible way. In this study lecturers were assigned to the committees by considering the lecturers' and the management team's preferences.

Assignment problem can be defined as two sets of inputs; a set of resources and a set of demands (Moskon, 2011). In a lecturer-committee assignment problem, a set of lecturers is considered as the resources whereas a set of committees is the demands.

In the School of Quantitative Sciences (SQS), a set of committees were established to support SQS to achieve the Universiti Utara Malaysia (UUM) key performance indicators (KPIs). To achieve these KPIs, each committee requires a certain number of lecturers to organize activities within their job specifications. In this regard, lecturers need to commit to these committees to make sure all activities can be conducted to fulfil the KPIs.

There are 25 committees established in SQS, as presented in Table 1.1. Each committee is led by a chairperson, and the members of the committee are assigned manually by the SQS management team. The management team consists of the Dean, a Deputy Dean, an assistant registrar, two Head of Departments, and three programme coordinators.

Currently, the total number of active lecturers in SQS is 67, with eight administrative staff. However, only 54 lecturers are considered in this study as lecturers with managerial posts and international lecturers are excluded on the basis of automatic assignment by the Deputy Dean according to their suitability. The number of committee members in the last column of Table 1.1 is based on the data in 2020. Five committees have zero total members because of the exclusion of lecturers who are appointed by the SQS management team, international lecturers, and administrative staff.

Table 1.1

List of Committees in SQS

No.	Committee	Total members
1.	Student complaint	0
2.	Strategic and quality	0
3.	Admission and certification	0
4.	Examination and graduation	3
5.	E-learning	0
6.	Student development and alumni (JKPPAPP)	7
7.	Research and consultation	4
8.	Publication	4
9.	Promotion and internationalization	6
10.	Seminar and training	7
11.	Human capital development	5
12.	Practicum	3
13.	Memorandum of understanding (MoU)	5
14.	Wellbeing and safety	7
15.	QS ranking	4
16.	Accreditation	3
17.	International Organization for Standardization (ISO)	10
18.	Commercialization and innovation	4
19.	Website and social media	4
20.	Innovative and creative group	3
21.	Survey	6
22.	Entrepreneurship	3
23.	Community	4
24.	SQS Statistical Consulting (SQSSC)	8
25.	Liaison librarian	0

Based on the data in 2020 provided by the Deputy Dean, each lecturer is assigned to one to two committees (including lecturers appointed as the chairperson of a committee). The assignment of lecturers-committees is adjusted every year. The process of the assignment starts by appointing the chairperson of each committee. Then, each chairperson was asked to suggest the members of their committee. In addition, there are also some committees that require administrative staff to join, such as the Entrepreneurship, Innovative and creative group, Website and social media, as well as Well-being and safety. Therefore, all administrative staff in SQS are also assigned to at least one committee. However, the final decision of the assignment depends on the availability and suitability of the administrative staff and the lecturers.

1.2 Problem Statement

All KPIs assigned to each committee must be achieved every year. They are quarterly evaluated and must be reported to UUM, particularly by the strategic and quality committee. Thus, unwavering commitments from the committee's members are crucial to ensure successful activities organized by the committee in order to fulfil the KPIs.

Currently, lecturers are assigned manually to the committees by the SQS management team. This practice may have two drawbacks, such as the management team needs to consider a lecturer's request to change to another committee of their preference. This would cause the management team to spend more time trying to fulfil the demands from the lecturers. In addition, the management team needs to assign the lecturers to the committees annually. Since there are changes in the number of lecturers every year, the management team needs to re-allocate the lecturers to new committees each year. Hence it would take a longer time for the whole process to complete.

The second drawback is this practice may also cause a lack of commitment from the lecturers due to the lack of interest towards their assigned committees. Furthermore, the lecturers may not demonstrate good performance as a committee member because they do not have interest to perform in the committee assigned to them. Therefore, before the management team assigns a lecturer to a committee, they must know the lecturers' preference.

1.3 Research Questions

The research questions in this study are:

i. What are the parameters and constraints required for the assignment problem?
ii. Which committees are preferred by each lecturer?
iii. How to maximize the total preference weight of the lecturers?
iv. How to evaluate the proposed solution in this study?
v. What is the suitable sensitivity analysis required by this study?

1.4 Research Objectives

The main objective of this study is to develop an IP model by considering the lecturers' and the management team's preferences in solving the SQS lecturer-committee assignment problem. To achieve the main objective, there are some specific objectives that need to be fulfilled, which are:

i. To identify the parameters and constraints required for the assignment problem.
ii. To determine the preference weight of each lecturer towards the proposed committees.
iii. To develop an integer programming model to maximize the total preference weight of the lecturers.

iv. To evaluate the proposed solution and the current practice in terms of the total preference weight.

v. To develop suitable sensitivity analysis models related to the SQS lecturer-committee assignment problem.

1.5 Scope of the Study

This study was conducted at SQS, UUM. The data used in this study involves 54 active lecturers (excluding lecturers appointed in the SQS management team and international lecturers) and 20 committees (excluding committees made up of members appointed by the SQS management team and international lecturers) in 2020.

1.6 Significance of the Study

The proposed IP model would assist the SQS management team in assigning lecturers to their committees by taking into consideration the lecturers' preferences as well as the preference of the SQS management team. It is hoped that by considering both preferences, the optimal solution obtained from the IP model may increase the satisfaction and commitments of the SQS lecturers towards their assigned committees in order to fulfil the UUM's KPIs.

1.7 Structure of Thesis

There are five chapters in this study. Chapter one starts with the introduction of the assignment problem and the lecturers-committee assignment problem in SQS. Then, the problem statement, research questions, research objectives, scope of the study, and significance of the study are presented at the end of the chapter.

Chapter two discusses the literature review related to the study. This chapter consists of past studies on general assignment problems, assignment problems within the education domain, and the techniques used for the assignment problems.

Chapter three describes the methodology used to solve the lecturer-committee assignment problem in SQS. The descriptions include the research framework and research processes.

Chapter four presents the optimal solution obtained from the IP model and the three solutions of the sensitivity analysis models. Comparisons between these solutions are also presented at the end of this chapter.

Chapter five concludes the research of this study. This chapter consists of a conclusion, limitation of study and future recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews examples of past studies that solved assignment problems. Then, the techniques used to solve the problems are presented at the end of the chapter.

2.2 Assignment Problem in Education Domain

This section discusses past studies that solved assignment problems in the education domain. Examples of the problems are the teacher assignment problem, assigning students to elective courses, allocating a project supervisor to students, and assigning the faculty team and rooms to the courses to be taught.

Gunawan, Ng, and Poh (2007) used the hybrid algorithm to solve the teacher assignment course timetabling problem at an institute in Indonesia. They need to assign and arrange the teachers to the courses and course sections, at the same time, contemplating the number of courses offered and teachers' preferences. The study applied the hybrid algorithm, which combined with an integer programming to solve large problem size. Furthermore, a simulated annealing algorithm has been modified, and greedy heuristic was utilized collaboratively to resolve the problem.

Domenech and Lusa (2016) used mixed integer linear problem solving the teacher assignment problem. Two standards need to consider assigning teachers to course. The first standard was to balance the teachers' teaching load while the next standard was to maximize the teachers' preferences for the course according to their category. School of Industrial Engineering in Barcelona is the place where the study was conducted, and the number of teachers in the study was 50, and the number of courses was 200.

Moreover, Gunawan and Ng (2011) resolved the teacher assignment problem by using two algorithms at an institute in Indonesia. The two algorithms are tabu search (TS) and simulated annealing (SA). The study focuses on the capacity of the class to manage register students. Therefore, the first thing that needs to do in their study is that they must decide the number of courses required to be allocated to each teacher after that is to allocate the teachers to course sections. Besides, the proposed algorithm was used to evaluate the performance. There are two sets of real data that was obtained from an institute, and some data set were generated randomly. The computational outcomes showed that tabu search and simulated annealing algorithms created better results compared to past works.

Meanwhile, Beroš and Meter (2015) concentrated on assigning students to elective courses at an academic institution in Croatia based on the students' preferences. To maximize the student's satisfaction, they used the integer programming model. The integer programming models were established according to an educational institution's operational demands and students' preferences. The study conducted 166 students. Students can choose courses that they like by rank, the courses they prefer, and for every course, there are a limited number of students that can be registered. The models proved that it could reduce the time institution management to assign students to elective courses and at the same time, maximize the satisfaction of students.

Salami and Mamman (2016) allocate project supervisors to students, according to students' preferences by using a genetic algorithm. There were three constraints in their study: the number of lecturers per students, the number of students per lecturer and the number of students per project topic. The MATLAB R2010a was used to solve the problem. The model was successfully proved it could allocate project supervisors to students.

Ferreira (2015) used operation research by solving integer programming instances and artificial intelligence according to local searches to assign professors to classes. There were three constraints in the study. Firstly, each professor is correlated with two scientific skills. Next, the course must offer each week, and each course must have a certain number of course sections. Lastly, all professors are available. The result showed that, the best technique to assign professors to classes is operations research.

2.3 Assignment Problem in Other Domains

This section reviews applications of assignment problems that have been solved in other domains such as health, transportation, and agriculture.

Taramasco *et al.* (2019), Dorgham *et al.* (2019) and Guido *et al.* (2018) have solved the patient bed assignment problem. According to Taramasco *et al.* (2019), beds were assigned to patients. By using the assignment problem, they can match patients with the bed. The autonomous bat algorithm was used to solve patient bed assignment problem. Dorgham *et al.* (2019) concentrated on allocating patients to beds. To allocate patients to the bed, they used a hybrid simulated annealing algorithm. By using metaheuristic method Guido *et al.* (2018) resolve the patient bed assignment problem in their study.

Moreover, the assignment problem has been used to resolve the issue in transportation. For instance, Binder *et al.* (2017) applied assignment problem to allocate passengers, according to priority in the capacitated public transportation network. They constructed a new framework for the timetable-based passenger assignment problem.

Arkhipov *et al.* (2018) presented to assign tasks to accessible operators in the aircraft assembly lines. They construct new optimization approaches based on the integer programming models and constraint programming. Both approaches can be applied to resolve the operator assignment problem.

Assign regular time windows to its delivery locations also is one of application assignment problems in transportation (Neves-Moreira et al., 2018). There were two stages in their study. Firstly, assign a set of time windows to each location. Then they defined the delivery timetable respecting the assigned time windows. The authors used a novel mathematical formulation to reduce the total cost experienced in fleet demands and travelled distance.

Lone *et al.* (2017) also applied assignment problem to allocate paddock to crop. The R-software was used to solve the issue. The study used a mathematical modelling framework for crop assignment to the fields using the integer programming.

In addition, the application of the assignment problem is in laptop selection. The study aimed was to reduce the cost as per user demand. Revised Ones Assignment (ROA) method is used to solve the problem. While MATLAB is used to verify and gives an optimal solution within 0.005256 sec (Kirtiwant & Yogesh, 2015).

Li *et al.* (2017) resolve the bi-objective weapon-target by using assignment problem. They come up with an improved Pareto ant colony optimization in their study. In contrast, Karsu and Azizoglu (2019) used linear programming and mixed integer nonlinear to allocate tasks to agents. The study aimed to reduce the sum of square loads of all agents. The results showed that the model could allocate 45 tasks to ten agents and 70 tasks to five agents.

2.4 Techniques Used for Solving Assignment Problems

This section discusses several approaches that have been established to find the best solutions for the assignment problems such as exact method, heuristic method, and metaheuristic method. The exact method would provide an optimum solution and evaluate it optimally. Examples of exact methods are linear programming, integer programming, and dynamic programming. The heuristic method tries to produce a good outcome. However, it is not sure that it would provide an optimal solution. Meanwhile, there are two categories for metaheuristic method: population search-based and local search (Faudzi, Rahman, & Rahman, 2018).

The exact method is suitable to solve small size problems. While heuristic method suitable to solve real sized problems to obtain estimate solutions. According to Ray (2016), by using a heuristic, the solution is not particular whether optimal or not. However, it is sufficient for instant goals and would increase the finding an acceptable solution. A procedure performed in search of good quality solutions is known as heuristic technique. There are many heuristic approaches has been established because of the difficulties experienced to develop the exact solution procedures.

Lin *et al.* (2016) applied the exact method, mixed-integer programming model to resolve the therapist assignment problem in home healthcare. The study concentrated on assigning a therapist to a patient by considering the patient's compatibility. Two aspects were expressed in the therapist assignment problem: therapist and patient. The therapist was classified based on their skills. In contrast, the patient was classified based on the patient's priority and continuity of care levels. To maximize the workload utilization rate of a therapist under overtime based is the main purpose of the therapist assignment problem. This main purpose would help therapists to give full dedication without feeling exhausted. The outcome of the study is the total number of assigned patients was decreased slightly.

Ongy (2017) created a 0-1 integer programming (IP) model to assign faculty to course schedule based on the capability on the personal preference and courses in the faculty's timetable. The problem was solved using Microsoft Excel. Constraints in the study are 76, and decision variables are 38. By considering three terms, the developed model can provide positive feedback: personal preferences on the time schedules and subject matter, compelling the policies and provisions of the institutions.

Anwar and Bahaj (2003) resolve the issue to assign projects to students. The data were collected from 2001 until 2002, which involved 60 projects and 39 sophomore students. There were two IP models used to resolve the issue. The objective of the first model was to reduce the quantity of project supervised by each staff member, whereas the other model was to assign a project according to the ranking of students' preferences. The outcome between the two methods was compared, and it showed to be both computationally more organized and better in quality.

Abu Bakar, Hashim, and Bidin (2018) created a 0-1 integer linear programming to form student groups for three English classes at Universiti Utara Malaysia, which were offered in the July 2016/2017 academic session. There were 32 students in one of the classes, and the teacher decided to create many small groups. The aim was to maximize the total number of groups formed. The 0-1 integer linear programming model contains 173 constraints and 330 binary variables. The outcomes showed that the model could solve a classroom management problem.

A current study by Srivarapongse and Pijitbanjong (2019) showed that a heuristic method has the escalation and the diverseness capability to resolve a medium and large instance. The study aimed was to assign reapers to yield sugar in sugarcane fields. Therefore, it can maximize the profit from selling sugarcane. In the proposed heuristic, they provided a differential evolution (DE) algorithm. There are five steps in the modified DE. The number of fields ranged from six to 73 were used to present small to large problems. They developed a mathematical model and resolved the issue using Lingo version 11. Five heuristics were developed to solve large problems. The optimal solution can be found by using Lingo version 11. However, the capability of Lingo version 11 to solve the problems reduce if the size of the problem grows.

The iterative generation process is known as metaheuristic. Metaheuristic can be used to solve complex problems. For instance, simulated annealing (SA), genetic algorithm (GA), and tabu search (TS). SA resembles the annealing process in crystalline solids, GA similar to the transformative process in nature, and TS use the memory structure in living beings (Abd *et al.*, 2014)

Jang and Kim (2014) presented two metaheuristic algorithms; TS and particle swam optimization (PSO) to resolve a reliable server assignment problem. A reliable server assignment problem is to decide the distribution of servers to maximize the measure of services availability. The performance of both metaheuristics was rate on three examples in which 80 test problems were collected for each example. The performance was evaluated according to the average execution time, optimality rate, maximum relative error, and average relative error. Computational results showed that TS was more excellent than PSO.

Another study that used metaheuristics was Aktel *et al.* (2016). They utilize TS and SA to resolve an airport gate assignment problem. The problem aims to assign each flight to an access gate and at the same time maximizing gate utility and reduce passengers walking distance. The problem involved 23 gates and 184 flights. Experimental results showed that both metaheuristics were effective in solving a large-size gate assignment problem.

Table 2.1

Summary of Past Studies

Reference	**Assignment problem**	**Data size (total variables)**	**Technique (exact method/heuristic /metaheuristic)**
Domenech and Lusa (2016)	Assign teachers to courses	10000	Exact method
Beroš and Meter (2015)	Assign students to courses	3846	Exact method
Ferreira (2015)	Assign teachers to classes	748	Exact method
Lone et al. (2017)	Assign paddock to crop	16	Exact method
Graf Plessen (2019)	Assign crops to fields	40	Exact method
Kirtiwant and Yogesh (2015)	Assign laptops to users	84	Exact method
Karsu and Azizoglu (2019)	Assign tasks to agents	350	Exact method
Lin et al. (2016)	Assign therapists to patients	420	Exact method
Ongy (2017)	Assign faculty to course	78	Exact method
Anwar and Bahaj (2003)	Assign projects to students	2340	Exact method
Abu Bakar, Hashim, and Bidin (2018)	Assign students to groups	320	Exact method
Taramasco et al. (2019)	Assign beds to patients	900	Heuristics
Guido et al. (2018)	Assign patients to beds	72581196	Heuristic
Binder et al. (2017)	Assign passenger to capacitated public transportation network	195000	Heuristic
Arkhipov et al. (2018)	Assign tasks to operators	2023	Heuristic
Neves-Moreira et al (2018)	Assign regular time windows to delivery location	200	Heuristic
Li et al. (2017)	Assign weapons to targets	120	Heuristic

Srivarapongse and Pijitbanjong (2019)	Assign reapers to yield sugar	9563	Heuristic
Gunawan, Ng, and Poh (2007)	Assign teachers to courses	1800	Metaheuristic
Salami and Mamman (2016)	Assign projects to supervisors	286	Metaheuristic
Dorgham et al. (2019)	Assign patients to beds	70261926	Metaheuristic
Jang and Kim (2014)	Assign server to node	600	Metaheuristic
Aktel *et al.* (2016)	Assign flights to available gates	1932	Metaheuristic

Table 2.1 summaries the past studies that have been discussed in this chapter. From the table it shows that exact methods can be used to solve assignment problems with a data size below 10000. In other words, optimal solution is possible to be obtained for the problem. However, for a large data size, heuristics and metaheuristics are more practical since optimal solution is hard to be obtained.

2.5 Summary

In this chapter, examples of assignment problems in various domains and the techniques used to solve the problems are discussed. Overall, three approaches can be used to solve the problems such as exact methods, heuristics, and metaheuristics algorithms depending on the size of data involved in the problem.

In this study, an exact method particularly, the IP model is used to solve a lecturer-committee assignment problem in SQS. The data involves 20 committees and 54 lecturers.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the methodology used to solve the lecturer-committee assignment problem. The descriptions include the research framework and research processes.

3.2 Research Framework

Figure 3.1 depicts the research framework of this study. There are six stages conducted to achieve the research objectives.

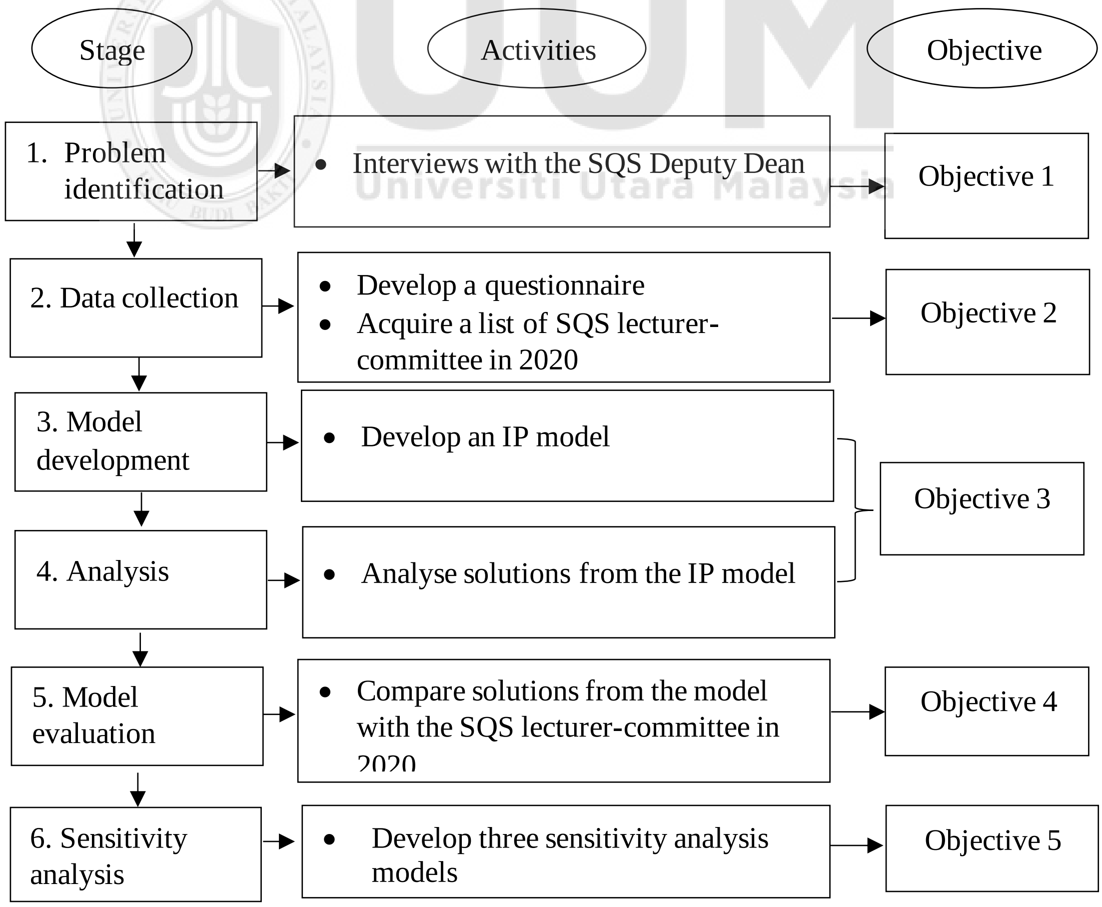

Figure 3.1 Research Framework

3.3 Research Process

This section describes the six stages conducted in this study, as shown in Figure 3.1.

3.3.1 Stage 1: Problem identification

This study aims to assign SQS lecturers to committees by considering lecturers' and management team's preferences. It is hoped that the proposed solution may satisfy both sides; the lecturers and the management team. In this section, interviews with the management team, mainly the SQS Deputy Dean was conducted to identify the parameters and constraints that must be considered in solving the lecturer-committee assignment problem. Data collected in this stage would achieve research objective 1 .

3.3.2 Stage 2: Data collection

There are two types of data involved in this study, namely the primary and secondary data. Primary data is collected through the following activities:

i. interviews with the Deputy Dean to identify the suitable committee for each lecturer.

ii. distribution of questionnaires to the SQS lecturers to determine their preferences on the committees as suggested by the Deputy Dean.

The questionnaire consists of two sections; demographic information and the potential committee placement (referred to Appendix A). In the first section, the questions asked were the lecturer's name and their department. There are 25 lecturers in the Decision Science Department and 29 lecturers in the Mathematics and Statistics Department. While in the second section, there were two questions; the first was the lecturer's preference weight over the Deputy Dean's proposed committee placement. The preference weight is ranked as below:

1: Low preference

2: Moderate

3: High preference

According to Lehmann and Hulbert (1972) three-point scales are adequate to meet criteria predictive validity, test-retest reliability, and concurrent validity. While Taherdoost (2019) proposed the reliability and validity are independent of the number of scales. Thus, reliability and validity would not be decreased if the number of response choices decreases. Besides, three-point is one of scales received the most preferred rating scales by respondents.

The second question was the lecturer's selection of their preferred committee. Lecturers could choose a committee of their liking from the 20 committees listed.

On the other hand, secondary data is provided by the Deputy Dean, particularly the list of lecturer-committee assignment in 2020. Both data collected in this stage would achieve research objectives 2.

3.3.3 Stage 3: Model development

An IP model developed to solve the SQS lecturer-committee assignment problem is shown below:

$$\text{Maximize } Z = \sum_{i=0}^{54}\sum_{j=0}^{20} P_{ij}\, X_{ij} \tag{3.1}$$

Subject to

$$\sum_{j=1}^{20} x_{ij} \geq C_i, \forall i \tag{3.2}$$

$$\sum_{j=1}^{20} x_{ij} \leq C_i, \forall i \qquad (3.3)$$

$$\sum_{i=1}^{54} x_{ij} = L_j, \forall j \qquad (3.4)$$

$$X_{ij} = 1 \text{ or } 0 \qquad (3.5)$$

where

Z = total preference weight of lecturers

C_i = number of committees of lecturer *i* (*i* = 1,.., 54)

L_j = number of lecturers of committee *j* (*j* = 1,.., 20)

P_{ij} = preference weight of lecturer *i* to committee *j*

X_{ij} = 1 if lecturer *i* is assigned to committee *j*; 0 otherwise

The objective function of the IP model is to maximize the total preference weight of lecturers, Z which is calculated in Equation (3.1). The P_{ij} used in this model is obtained from the questionnaire feedbacks (refer to Appendix B).

Problem constraints for the lecturers, committees, as well as decision variables are defined from (3.2) to (3.5). Equations (3.2) and (3.3) ensure that each lecturer (*i*=1, …, 54) is assigned to only one (C_i=1) or two (C_i=2) committees, respectively. Equation (3.4) indicates that each committee (*j*=1, …, 20) will get L_j members (refer to Table 1.1). Finally, Equation (3.5) ensures that the decision variable, X_{ij} can only receive 1 or 0 (X_{ij}=1 if lecturer *i* is assigned to committee *j*, otherwise X_{ij}=0). The expansion of this IP model is presented in Appendix C.

3.3.4 Stage 4: Analysis

After the development of the IP model is completed, OpenSolver was used to run the model. OpenSolver is an open source Excel add-in that allows spreadsheet users to solve their Linear Programming (LP)/IP models using the COIN-OR CBC solver. The COIN-OR CBC solver written in C++ and it is an open-source mixed integer program. OpenSolver is largely compatible with the built-in Excel Solver, allowing most existing LP and IP models to be solved without changes. Furthermore, it can be optimized without artificial limits on problem sizes. Therefore, OpenSolver is suitable to solve the lecturer-committee assignment problem which involves 1080 variables (54 lecturers x 20 committees). Optimal solution obtained from the model was analysed in terms of total preference weight of the lecturers. The outcomes from stage 3 and stage 4 would achieve research objective 3.

3.3.5 Stage 5: Model evaluation

Comparison between two solutions; current practice (solution constructed manually by SQS management team in 2020) and the proposed solution from this study (optimal solution obtained from the IP model) were compared in terms of the total preference weight. The comparison results in this stage would achieve research objective 4.

3.3.6 Stage 6: Sensitivity analysis

Three sensitivity analysis models related to the SQS lecturer-committee assignment problem were developed in this study. The objective function of these models is similar to Equation (3.1) where all models aim to maximize the total preferences weight of the lecturers. Constraints for the committees, Equation (3.4) and the decision variables, Equation (3.5) are also similar with the sensitivity analysis models. The difference between the models is only on the lecturer's constraints.

i) Sensitivity analysis (1)

In this model, the chairperson of each committee and the director of School Center of Excellence (SCoE) are assigned to only one committee as defined in Equation (3.6), whereas the other lecturers are assigned to at least two committees as defined in Equation (3.7).

$$\sum_{j=1}^{20} x_{ij} = 1 \tag{3.6}$$

$where\ i = 2, 3, 7, 8, 10, 11, 12, 15, 17, 19, 21, 22, 23, 25, 27, 28, 30, 39, 52$

$$\sum_{j=1}^{20} x_{ij} \geq 2 \tag{3.7}$$

where $i = 1, 4, 5, 6, 9, 13, 14, 16, 18, 20, 24, 26, 29, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 53, 54$

Based on the data provided by the Deputy Dean, 18 lecturers are appointed as the chairperson while one lecturer is appointed as the director of SCoE. Table 3.1 presents the ID of these lecturers who are appointed to only one committee.

Table 3.1

Lecturer assigned to One Committee

Position	**Lecturer ID**
Chairperson of a committee	2, 3, 7, 8, 10, 11, 12, 15, 17, 19, 21, 23, 25, 27, 28, 30, 39, 52
Director of SCoE	22

The remaining 35 lecturers who do not hold any positions are assigned to at least two committees. The expansion of Equation (3.6) and (3.7) are presented in Appendix D.

This model is developed based on the assumption that more workload and commitment are expected from the chairpersons and the director of SCoE to organize activities that will help SQS to achieve UUM's KPIs.

ii) Sensitivity analysis (2)

In this model, 54 lecturers are assigned to at most two committees without considering their position (i.e. chairperson or director). Equation (3.8) ensures that each lecturer gets between 0 and 2 committees. The right-hand side is set to less than or equal to two. Lecturers who did not get any committee assignment indicate that they gave low preferences to the potential committees suggested by the Deputy Dean in the questionnaire.

$$\sum_{j=1}^{20} x_{ij} \leq 2, \forall i \quad (3.8)$$

iii) Sensitivity analysis (3)

In this model, all lecturers are assigned to at least one committee. The purpose of developing this model is to identify the maximum number of committees that can be assigned to a lecturer. Lecturers who get the most committees indicate that they gave high preference to the potential committee suggestion by the Deputy Dean. The lecturer's constraint for this model is presented in Equation (3.9). The right-hand side is set to greater than or equal to one.

$$\sum_{j=1}^{20} x_{ij} \geq 1, \forall i \quad (3.9)$$

Three sensitivity analysis models developed in this stage would achieve the research objective 5.

3.4 Summary

There are six stages conducted in this study. The first stage identified suitable parameters and problem constraints. The second stage collected two types of data used in this study. The next stage developed an IP model to solve the SQS lecturer-committee assignment problem. After the development of an IP model, OpenSolver was used to run the model. The fifth stage evaluated the model where the current practice and the proposed solution were compared. The last stage developed three sensitivity analyses.

CHAPTER FOUR

RESULT AND ANALYSIS

4.1 Introduction

This chapter presents the result and analysis of four IP models developed in this study. The first model is the proposed model which is based on the problem constraints determined from the data provided by the Deputy Dean. The result obtained from this model is the optimal solution for solving the lecturer-committee assignment problem in SQS.

The remaining three models are developed for sensitivity analysis with different lecturers' constraints related to the assignment problem. Comparison results between these models and the current committee assigned to the SQS lecturers in 2020 are presented at the end of this chapter. The result with the highest total preference weight of the lecturers is the best solution for SQS lecturer-committee assignment problem.

4.2 Questionnaire Feedbacks

Of the 54 questionnaires distributed to the SQS lecturers, we received a 94.4% return rate. Unreturned questionnaires were assumed to have high preference (weight three) to the committee suggested by the Deputy Dean.

4.3 Analysis of Proposed Solution

The proposed solution was obtained using the OpenSolver to determine the optimal lecturer-committee assignment based on the Deputy Dean recommendation and lecturers' preference. Table 4.1 presents the optimal solution for the assignment problem. It shows a list of committees that were assigned to each lecturer. Based on the table, 46 lecturers were assigned to two committees, while another eight lecturers were assigned to only one committee. The eight lecturers were assigned to only one committee because they have low preference weight (weight is one) for most of the committees suggested by the Deputy Dean. The preference weight assigned to the committees by each lecturer is also presented in the last column of Table 4.1. The total preference weight obtained from this optimal solution is 265.

Table 4.1

Optimal Solution from the Proposed Model

Lecturer ID	Committee	Number of Committees	Preference weight
1	Promotion and internationalization, Innovative and creative group	2	3, 3
2	MoU, Community	2	2, 3
3	Wellbeing and safety	1	3
4	Survey, SQSSC	2	1, 3
5	ISO	1	3
6	Research and consultation, MoU	2	3, 2
7	Website and social media	1	3
8	Human capital development, Accreditation	2	3, 2
9	Seminar and training, Human capital development	2	3, 3
10	Entrepreneurship, SQSSC	2	3, 2
11	Promotion and internationalization, SQSSC	2	3, 3
12	Accreditation, ISO	2	3, 2
13	JKPPAPP, Survey	2	2, 3
14	MoU, Survey	2	2, 3
15	Human capital development, Wellbeing and safety	2	2, 3
16	Research and consultation, Innovative and creative group	2	3, 3
17	Website and social media	1	3
18	Publication, Seminar and training	2	3, 2
19	JKPPAPP, QS ranking	2	3, 3
20	Seminar and training, Commercialization and innovation	2	3, 2
21	Research and consultation, Publication	2	3, 3
22	QS ranking, Community	2	3, 3

23	Survey, SQSSC	2	3, 3
24	JKPPAPP, Human capital development	2	3, 3
25	JKPPAPP, Survey	2	2, 3
26	Practicum	1	3
27	Practicum, Commercialization and innovation	2	3, 2
28	Wellbeing and safety, ISO	2	3, 1
29	Publication	1	3
30	Practicum, MoU	2	3, 2
31	Wellbeing and safety, SQSSC	2	3, 2
32	ISO, SQSSC	2	3, 3
33	Promotion and internationalization, Accreditation	2	2, 3
34	Commercialization and innovation	1	3
35	Website and social media, Innovative and creative group	2	3, 3
36	JKPPAPP, ISO	2	3, 3
37	Commercialization and innovation, Entrepreneurship	2	3, 3
38	Research and consultation, Publication	2	3, 3
39	Seminar and training, SQSC	2	3, 2
40	Promotion and internationalization, QS ranking	2	1, 1
41	Promotion and internationalization, ISO	2	3, 3
42	Promotion and internationalization, Seminar and training	2	3, 2
43	Exam and graduation, Wellbeing and safety	2	3, 3
44	ISO, Community	2	2, 2
45	JKPPAPP, Website and social media	2	3, 3
46	Wellbeing and safety, ISO	2	3, 2
47	Exam and graduation, Seminar and training	2	3, 2
48	Exam and graduation, Survey	2	3, 3
49	ISO, Community	2	2, 2
50	Wellbeing and safety, Entrepreneurship	2	3, 2
51	Human capital development,	1	3
52	Seminar and training, QS ranking	2	3, 3
53	ISO, SQSC	2	3, 3
54	JKPPAPP, MoU	2	2, 1

4.4 Comparison between Current Practice and Optimal Solution

In the current practice, members of each committee were assigned manually by the SQS management team. On the other hand, the optimal solution proposed in this study takes into consideration the lecturers' preferences. Thus, Table 4.2 compares the lecturers' assignment to their committee between the optimal solution and the current practice. The total preference weight of each committee for both solutions is also presented in Table 4.2. A higher total weight indicates higher preferences by the members to the committee.

Table 4.2

Comparison of Preference Weight by Committee

Committee	Optimal solution		Current practice	
	Lecturer ID	Total preference weight	Lecturer ID	Total preference weight
Exam and graduation	43, 47, 48	9	***26***, ***44***, 48	9
JKPPAPP	13, 19, 24, 25, 36, 45, 54	18	***2, 17***, 25, ***26, 27***, 45, 54	12
Research and consultation	6, 16, 21, 38	12	***9, 15***, 16, ***39***	8
Publication	18, 21, 29, 38	12	***15***, ***23,*** 38, ***39***	9
Promotion and internationalization	1, 11, 33, 40, 41, 42	15	1, ***10,*** 11, 33, 40, 41	13
Seminar and training	9, 18, 20, 39, 42, 47, 52	18	***3***, ***6***, 18, ***34***, ***36***, 42, 47	13
Human capital development	8, 9, 15, 24, 51	14	***3***, 9, ***18,*** 51, ***52***	11
Practicum	26, 27, 30,	9	***7***, ***12,*** 30	9
MoU	2, 6, 14, 30, 54	9	2, 6, 14, 30, ***42***	9
Wellbeing and safety	3, 15, 28, 31, 43, 46, 50	21	***13***, ***21***, 28, 31, ***41***, ***44***, ***49***	17

QS ranking	19, 22, 40, 52	10	19, 40, ***46***, 52	8
Accreditation	8, 12, 33	8	12, ***14***, ***38***	8
ISO	5, 12, 28, 32, 36, 41, 44, 46, 49, 53	24	5, ***21,*** 28, ***29***, 32, 36, ***43***, 46, 49, 53	20
Commercialization and innovation	20, 27, 34, 37	10	***8***, 20, 27, 37	8
Website and social media	7, 17, 35, 45	12	7, 17, 35, 45	12
Innovative and creative group	1, 16, 35	9	1, 16, 35	9
Survey	4, 13, 14, 23, 25, 48	16	13, ***24***, 25, ***33***, ***47***, 48	14
Entrepreneurship	10, 37, 50	8	***23***, ***24***, 50	7
Community	2, 22, 44, 49	10	***8,*** 22, ***34***, ***54***	7
SQSSC	4, 10, 11, 23, 31, 32, 39, 53	21	4, 10, 11, ***20,*** 31, 32, ***50***, 53	18

Based on Table 4.2, lecturers who been italic and bold in the current practice means they do not assign to the same committees as in the optimal solution. However, there are 2 committees (Website and social media committee, Innovative and creative group) assign the same lecturers as the current practice. This is because in the current practice the lecturers for these two committees were asked for their preferences before the assignment. The total number of lecturers in each committee for optimal solution and current practice is similar (one of the committee's constraints in the IP model). In addition, there are six committees with same total preference weight. For example, website and social media committee have a total preference weight of 12.

Table 4.3 presents the total preference weight of each lecturer based on the committee(s) assigned to them. Based on Table 4.3, the highest total weight is six, whereas the lowest total weight is one. Lecturers who get six total preference weight indicate that they were assigned to two committees with high preferences for both committees. On the other hand, lecturers who get only one total preference weight indicate that they were assigned to only one committee with low preference to the committee.

Table 4.3

Comparison of Preference Weight by Lecturer

Lecturer ID	Optimal Solution	Current Practice
1	6	6
2	5	4
3	3	2
4	4	3
5	3	3
6	5	4
7	3	6
8	5	2
9	6	5
10	5	3
11	6	6
12	5	6
13	5	6
14	5	5
15	5	2
16	6	6
17	3	4
18	5	3
19	6	3
20	5	3
21	6	2
22	6	3
23	6	5
24	6	4
25	5	5
26	3	4
27	5	3
28	4	4
29	3	1
30	5	5
31	5	5
32	6	6
33	5	4
34	3	2
35	6	6
36	6	6
37	6	3
38	6	5
39	5	5

40	2	2
41	6	5
42	5	3
43	6	1
44	4	5
45	6	6
46	5	3
47	5	3
48	6	6
49	4	5
50	5	3
51	3	3
52	6	6
53	6	6
54	3	4
Total weight	**265**	**221**

Based on Table 4.3, the optimal solution provides a higher total preference weight compared to the current practice with an increment of 19.91%. In other words, the optimal solution proposed in this study is a better solution in solving the SQS lecturer-committee assignment problem.

4.5 Sensitivity Analysis

Sensitivity analysis concerns with how changes in some parameters in the proposed model may affect the current optimal solution. The sensitivity analysis in this study involves three scenarios which focuses on the changes of the lecturer's constraints.

4.5.1 Sensitivity Analysis (1)

In this model, 19 lecturers who were appointed as chairpersons of the committees and the director of SCoE were assigned to only one committee, while 35 lecturers were assigned to at least two committees. This scenario is proposed by considering the high responsibilities as the chairperson or the director to achieve the targeted KPIs set by the management. Table 4.4 presents the solution of the sensitivity analysis (1).

Table 4.4

Solution for Sensitivity Analysis (1)

Lecturer ID	Number of committees	Preference Weight
1	3	**8**
2	1	3
3	1	3
4	2	4
5	2	6
6	2	5
7	1	3
8	1	3
9	2	6
10	1	2
11	1	3
12	1	2
13	2	5
14	5	**13**
15	1	2
16	2	6
17	1	3
18	2	5
19	1	3
20	2	5
21	1	3
22	1	3
23	1	3
24	2	6
25	1	3
26	2	4
27	1	2
28	1	3
29	2	4
30	1	2
31	2	5
32	3	**9**
33	3	**7**
34	2	4
35	2	6
36	3	**9**
37	2	6
38	3	**9**
39	1	3
40	2	2
41	3	**9**
42	2	4
43	2	6
44	2	4

45	2	6
46	2	5
47	2	5
48	2	6
49	2	4
50	2	4
51	2	3
52	1	3
53	4	**12**
54	2	5
TOTAL		**259**

Based on Table 4.4, lecturers who get scored above 6 total preference weight were assigned to more than two committees (written in bold). These lecturers gave high preferences to the committees proposed by the Deputy Dean. Thus, this model assumes that they are willing to be the members of these committees. The total preference weight of this solution is 259 which is 17.19% higher than the current practice (preference weight is 221).

Table 4.5 summarises the number of lecturers who were assigned to at least two committees (based on the second column of Table 4.4)

Table 4.5

Member Assigned to at Least Two Committees

Number of Committees	Lecturer ID	Number of Lecturers
2	4, 5, 6, 9, 13, 16, 18, 20, 24,26, 29, 31, 34, 35, 37, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 54	27
3	1, 32, 33, 36, 38, 41	6
4	53	1
5	14	1
	Total lecturers	**35**

Based on Table 4.5, Lecturer 14 is assigned to the highest number of committees (five committees), followed by Lecturer 53 is assigned to four committees. This is supported by the data that all possible committees suggested by the Deputy Dean were given high preferences by Lecturer 14 and Lecturer 53. 27 lecturers were assigned to two committees and the remaining six lecturers were assigned to three committees.

4.5.2 Sensitivity Analysis (2)

In this model, all 54 lecturers were assigned to at most two committees without considering their positions (i.e. chairperson or director). Table 4.6 presents the solution of the sensitivity analysis (2).

Table 4.6

Solution for Sensitivity Analysis (2)

Lecturer ID	**Number of Committees**	**Preference Weight**
1	2	**6**
2	2	**5**
3	0	0
4	2	**4**
5	2	**6**
6	2	**5**
7	1	3
8	2	**5**
9	2	**6**
10	2	**5**
11	2	**6**
12	2	**5**
13	2	**5**
14	2	**5**
15	2	**5**
16	2	**6**
17	1	3
18	2	**5**
19	2	**6**
20	2	**5**
21	2	**6**
22	2	**6**
23	2	**6**

24	2	**6**
25	2	**5**
26	1	3
27	2	**5**
28	2	**4**
29	1	3
30	2	**5**
31	2	**5**
32	2	**6**
33	2	**5**
34	1	3
35	2	**6**
36	2	**6**
37	2	**6**
38	2	**6**
39	2	**5**
40	2	2
41	2	**6**
42	2	**5**
43	2	**6**
44	2	**4**
45	2	**6**
46	2	**5**
47	2	**5**
48	2	**6**
49	2	**4**
50	2	**5**
51	1	3
52	2	**6**
53	2	**6**
54	2	**3**
TOTAL		**265**

Based on Table 4.6, lecturers who get scored above 3 total preference weight were assigned to two committees (written in bold). These lecturers gave high preferences to the committees proposed by the Deputy Dean. Thus, this model assumes that they are willing to be the members of these committees. The total preference weight of this solution is 265 which is 19.91% higher than the current practice (preference weight is 221).

Table 4.7 summarises the number of lecturers who were assigned to at most two committees (based on the second column of Table 4.6).

Table 4.7

Lecturer Assigned to at Most Two Committees

Number of Committees	Lecturer ID	Number of Lecturers
0	3	1
1	7, 17, 26, 34, 51	5
2	1, 2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 52, 53, 54	48
	Total lecturers	**54**

According to Table 4.7, Lecturer 3 was not assigned to any committee. Lecturer 3 gave low preference weight of one for two committees. As for the other committee, Lecturer 3 gave high preference weight of three. Even so, OpenSolver did not assign Lecturer 3 to that committee because it was a preferred choice by many other lecturers who also gave three preference weight. Therefore, Lecturer 3 was not assigned to any committee in the sensitivity analysis (2). Five lecturers were assigned to one committee and the remaining 48 lecturers were assigned to two committees. They were assigned to two committees because they mostly gave preference weight between two and three for the committee suggested to them.

4.5.3 Sensitivity Analysis (3)

The last sensitivity analysis was performed where all lecturers were assigned to at least one committee. Table 4.8 presents the solution of the sensitivity analysis (3).

Table 4.8

Solution for Sensitivity Analysis (3)

Lecturer ID	**Number of Committees**	**Preference Weight**
1	3	**8**
2	3	**7**
3	1	3
4	1	3
5	1	3
6	1	2
7	1	3
8	1	3
9	2	6
10	2	4
11	4	**12**
12	2	5
13	1	3
14	5	**13**
15	1	3
16	1	3
17	1	3
18	1	3
19	3	**9**
20	2	5
21	1	3
22	2	6
23	3	**9**
24	2	6
25	2	5
26	1	3
27	1	2
28	1	3
29	1	3
30	2	5
31	1	2
32	4	**12**
33	2	4
34	1	3
35	2	6
36	3	**9**
37	2	6
38	3	**9**
39	1	3
40	1	1
41	3	**9**
42	2	4
43	1	3
44	1	3

45	2	6
46	3	6
47	1	2
48	2	6
49	2	5
50	1	3
51	1	3
52	4	**12**
53	3	**9**
54	1	2
TOTAL		**274**

Based on Table 4.8, lecturers who get scored above 6 total preference weight were assigned to more than two committees (written in bold). These lecturers gave high preferences to the committees proposed by the Deputy Dean. Thus, this model assumes that they are willing to be the members of these committees. The total preference weight of this solution is 274 which is 23.98% higher than the current practice (preference weight is 221).

Table 4.9 summarises the number of lecturers who were assigned to at least one committee (based on the second column of Table 4.8).

Table 4.9

Lecturers Assigned to at Least One Committee

Number of Committees	Lecturer ID	Number of Lecturers
1	3, 4, 5, 6, 7, 8, 13, 15, 16, 17, 18, 21, 26, 27, 28, 29, 31, 34, 39, 40, 43, 44, 47, 50, 51, 54	26
2	9, 10, 12, 20, 22, 24, 25, 30, 33, 35, 37, 42, 45, 48, 49	15
3	1, 2, 19, 23, 36, 38, 41, 46, 53	9
4	11, 32, 52	3
5	14	1

TOTAL	54

Table 4.9 shows the highest number of committees assigned to a lecturer is five committees. There are two factors that lead Lecturer 14 to be assigned to five committees. Firstly, the preference weight Lecturer 14 gave to each committee is between two and three. Even though Lecturer 14 gave two as preference weight and OpenSolver still assigned Lecturer 14 to a committee, majority of the lecturers gave only one preference weight for that particular committee. Secondly, the Deputy Deans proposed four committees for Lecturer 14 and another committee is preferred by Lecturer 14. Therefore, Lecturer 14 has a high probability to get five committees.

Based on Table 4.9, 26 lecturers were assigned to one committee. The reason for these lecturers to be assigned to one committee is that they gave low preference weight to most committees suggested to them.

4.6 Summary

An IP model was developed in this study to maximize the total preference weight of lecturers in committee assignment problem. Comparison results between optimal solution and the current committee shown that optimal solution provides a higher total preference weight compared to the current committee. Three models were developed for sensitivity analysis. The highest total preference weight for sensitivity analysis is sensitivity analysis (3). While the lowest total preference weight between three sensitivity analysis is sensitivity analysis (1).

CHAPTER FIVE

CONCLUSION

5.1 Conclusion

This study seeks to solve the lecturer-committee assignment problem in SQS. The main aim of this study is to develop an IP model that takes into consideration both the lecturers' and management team's preferences in solving the SQS lecturer-committee assignment problem. The model was run by using OpenSolver. According to the results, the total preference weight of the optimal solution has a higher value compared to the total preference weight of the current practice. Therefore, the optimal solution proposed in this study provides a better solution to the lecturer-committee assignment problem in SQS.

Besides, there were three sensitivity analysis performed in this study. Sensitivity analysis (3) where all lecturers were assigned to at least one committee has the highest total preference weight of 274. However, it is not suitable to assign all lecturers to at least one committee in real-life application as some lecturers may be assigned to too many committees.

The most practical sensitivity analysis performed in this study is sensitivity analysis (1) where the chairpersons and the director of SCoE were assigned to one committee while the committee members could be assigned to at least two committees. However, the total preference weight for this sensitivity analysis is only 256 which is the lowest weight compared to sensitivity analysis (2) and (3). But if this solution is compared with the current practice, the total preference weight of this solution is 17.19% higher than the current practice.

Lastly, the sensitivity analysis performed where all lecturers were assigned to at least two committees has one lecturer who did not gets assigned to any committee. Therefore, it cannot be used in real-life application because there are possibilities of lecturers not getting assigned to any committee.

5.2 Limitations of the Study

There are two limitations in this study:

1. This study did not discuss the rank of committees selected by the lecturers.
2. This study only considers lecturers' preference but do not include their individual strength.

5.3 Recommendation

This study solved the lecturer-committee assignment problem in SQS. For future studies, the proposed IP model also can be used to solve the lecturer-committee assignment for other schools in UUM.

Moreover, a decision support system (DSS) for the lecturer-committee assignment problem can be developed. It would be easier for the management team to use the DSS with the help of a graphic user interface to assign lecturers to the committees.

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Appendix A

Example of the Questionnaire

A Lecturer-Committee Assignment Problem Using Integer Programming Model

*Required

SECTION 1: Demographic Information

Questions in this section are related to your general background.

1. Name *

Lecturer 1

2. Department *

- (●) Decision Science
- ( ) Mathematics and Statistics

SECTION 2: Potential Committees

Potential committees that had been listed in this section as proposed by the Deputy Dean.

1. Please indicate your preferences weights for the following committees. (3-High preference 2-Moderate 1-Low preference) *

	1	2	3
Akreditasi	○	◉	○
ISO	○	◉	○
Kumpulan inovatif dan kreatif	○	○	◉
Promosi dan pengantarabangsaan.	○	○	◉

2. If you have the opportunity to choose a committee, which of the following do you prefer? (for future years)

Promosi dan pengantarabangsaan ▾

Appendix B

Questionnaire Feedbacks

Lecturer	saan/peng	(JKPPAPP)	ikan& pe	enerbita	penganta	nar dan la	gunan mo	Praktikum	MoU	aan kesela	QS ranking	Akreditas	ISO	hersilan	e & socia	inovatif	kajiselidi	usahawar	Komuniti	SQSSC
Lecturer 1					3							2	2			3				
Lecturer 2		2							2										3	
Lecturer 3						1	1			3										
Lecturer 4																	1	1		3
Lecturer 5										3			3							
Lecturer 6		1	3			2			2					2						
Lecturer 7								3							3		1			
Lecturer 8				2			3					2		1					1	
Lecturer 9			2			3	3													
Lecturer 10					1								2					3		2
Lecturer 11					3	3				3										3
Lecturer 12								3				3	2							1
Lecturer 13	3	2								3							3			1
Lecturer 14									2			3					3	3		2
Lecturer 15			1	1			2			3										
Lecturer 16			3	3			1									3				
Lecturer 17		1													3					1
Lecturer 18				3		2	1			2										1
Lecturer 19		3	3								3	2								
Lecturer 20						3								2	2					1
Lecturer 21			3	3						1			1							1
Lecturer 22											3								3	
Lecturer 23				2													3	3		3
Lecturer 24		3					3										2	2		
Lecturer 25		2															3			
Lecturer 26	3	1	1	2				3												
Lecturer 27		1		2				3						2						
Lecturer 28										3			1		1					
Lecturer 29				3								1	1							
Lecturer 30								3	2											
Lecturer 31										3										2
Lecturer 32	3												3						3	3
Lecturer 33					2						1	3	2				2			
Lecturer 34						1								3		1			1	
Lecturer 35										3					3	3			1	1
Lecturer 36		3				3				3			3							
Lecturer 37				3										3			1	3		1
Lecturer 38			3	3				3				2								
Lecturer 39			2	3		3														2
Lecturer 40			1	1	1	1				3	1									
Lecturer 41					3					2		3	3							
Lecturer 42					3	2			1											
Lecturer 43	3									3			1							
Lecturer 44	3	1		3						2			2						2	
Lecturer 45		3													3	1				
Lecturer 46	1									3	1		2							
Lecturer 47	3					2				2							1			
Lecturer 48	3							3									3			
Lecturer 49										3			2						2	
Lecturer 50										3								2		1
Lecturer 51							3													
Lecturer 52			3	3		3	3				3									
Lecturer 53										3			3					3	3	3
Lecturer 54		2						3	1	3									2	

Appendix C

Integer Programming Model

Maximize $Z = \sum_{i=0}^{54} \sum_{j=0}^{20} P_{ij}\, X_{ij}$

Subject to

$\sum_{j=1}^{20} x_{ij} \geq 1, \forall_i$ (lecturer's constraint)

$\sum_{j=1}^{20} x_{ij} \leq 2, \forall_i$ (lecturer's constraint)

$\sum_{i=1}^{54} x_{ij} = L_j, \forall_j$ (committee's constraint)

X_{ij} = 1 or 0

Expansion of committee's constraint, $j = 1,\ldots,20$:

$x_{11} + x_{21} + x_{31} + x_{41} + x_{51} + x_{61} + \ldots\ldots\ldots\ldots + x_{541} = 3$

$x_{12} + x_{22} + x_{32} + x_{42} + x_{52} + x_{62} + \ldots\ldots\ldots\ldots + x_{542} = 7$

$x_{13} + x_{23} + x_{33} + x_{43} + x_{53} + x_{63} + \ldots\ldots\ldots\ldots + x_{543} = 4$

$x_{14} + x_{24} + x_{34} + x_{44} + x_{54} + x_{64} + \ldots\ldots\ldots\ldots + x_{544} = 4$

$x_{15} + x_{25} + x_{35} + x_{45} + x_{55} + x_{65} + \ldots\ldots\ldots\ldots + x_{545} = 6$

$x_{16} + x_{26} + x_{36} + x_{46} + x_{56} + x_{66} + \ldots\ldots\ldots\ldots + x_{546} = 7$

$x_{17} + x_{27} + x_{37} + x_{47} + x_{57} + x_{67} + \ldots\ldots\ldots\ldots + x_{547} = 5$

$x_{18} + x_{28} + x_{38} + x_{48} + x_{58} + x_{68} + \ldots\ldots\ldots\ldots + x_{548} = 3$

$x_{19} + x_{29} + x_{39} + x_{49} + x_{59} + x_{69} + \ldots\ldots\ldots\ldots + x_{549} = 5$

$x_{110} + x_{210} + x_{310} + x_{410} + x_{510} + x_{610} \ldots\ldots\ldots\ldots + x_{5410} = 7$

$x_{111} + x_{211} + x_{311} + x_{411} + x_{511} + x_{611}$ ………… $+ x_{5411} = 4$

$x_{112} + x_{212} + x_{312} + x_{412} + x_{512} + x_{612}$ ………… $+ x_{5412} = 3$

$x_{113} + x_{213} + x_{313} + x_{413} + x_{513} + x_{613}$ ………… $+ x_{5413} = 10$

$x_{114} + x_{214} + x_{314} + x_{414} + x_{514} + x_{614}$ ………… $+ x_{5414} = 4$

$x_{115} + x_{215} + x_{315} + x_{415} + x_{515} + x_{615}$ ………… $+ x_{5415} = 4$

$x_{116} + x_{216} + x_{316} + x_{416} + x_{516} + x_{616}$ ………… $+ x_{5416} = 3$

$x_{117} + x_{217} + x_{317} + x_{417} + x_{517} + x_{617}$ ………… $+ x_{5417} = 6$

$x_{118} + x_{218} + x_{318} + x_{418} + x_{518} + x_{618}$ ………… $+ x_{5418} = 3$

$x_{119} + x_{219} + x_{319} + x_{419} + x_{519} + x_{619}$ ………… $+ x_{5419} = 4$

$x_{120} + x_{220} + x_{320} + x_{420} + x_{520} + x_{620}$ ………… $+ x_{5420} = 8$

Appendix D

Sensitivity Analysis 1: Lecturer's constraints, *i* = 1,…,54

$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + \ldots\ldots\ldots\ldots + x_{220} = 1$

$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + \ldots\ldots\ldots\ldots + x_{320} = 1$

$x_{71} + x_{72} + x_{73} + x_{74} + x_{75} + \ldots\ldots\ldots\ldots + x_{720} = 1$

$x_{81} + x_{82} + x_{83} + x_{84} + x_{85} + \ldots\ldots\ldots\ldots + x_{820} = 1$

$x_{101} + x_{102} + x_{103} + x_{104} + x_{105} + \ldots\ldots\ldots\ldots + x_{1020} = 1$

$x_{111} + x_{112} + x_{113} + x_{114} + x_{115} + \ldots\ldots\ldots\ldots + x_{1120} = 1$

$x_{121} + x_{122} + x_{123} + x_{124} + x_{125} + \ldots\ldots\ldots\ldots + x_{1220} = 1$

$x_{151} + x_{152} + x_{153} + x_{154} + x_{155} + \ldots\ldots\ldots\ldots + x_{1520} = 1$

$x_{171} + x_{172} + x_{173} + x_{174} + x_{175} + \ldots\ldots\ldots\ldots + x_{1720} = 1$

$x_{191} + x_{192} + x_{193} + x_{194} + x_{195} + \ldots\ldots\ldots\ldots + x_{1920} = 1$

$x_{211} + x_{212} + x_{213} + x_{214} + x_{215} + \ldots\ldots\ldots\ldots + x_{2120} = 1$

$x_{231} + x_{232} + x_{233} + x_{234} + x_{235} + \ldots\ldots\ldots\ldots + x_{2320} = 1$

$x_{251} + x_{252} + x_{253} + x_{254} + x_{255} + \ldots\ldots\ldots\ldots + x_{2520} = 1$

$x_{271} + x_{272} + x_{273} + x_{274} + x_{275} + \ldots\ldots\ldots\ldots + x_{2720} = 1$

$x_{281} + x_{282} + x_{283} + x_{284} + x_{285} + \ldots\ldots\ldots\ldots + x_{2820} = 1$

$x_{301} + x_{302} + x_{303} + x_{304} + x_{305} + \ldots\ldots\ldots\ldots + x_{3020} = 1$

$x_{391} + x_{392} + x_{393} + x_{394} + x_{395} + \ldots\ldots\ldots\ldots + x_{3920} = 1$

$$x_{521} + x_{522} + x_{523} + x_{524} + x_{525} + \ldots\ldots\ldots\ldots + x_{5220} = 1$$

$$x_{221} + x_{222} + x_{223} + x_{224} + x_{225} + \ldots\ldots\ldots\ldots + x_{2220} = 1$$

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + \ldots\ldots\ldots\ldots + x_{120} \geq 2$$

$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + \ldots\ldots\ldots\ldots + x_{420} \geq 2$$

$$x_{51} + x_{52} + x_{53} + x_{54} + x_{55} + \ldots\ldots\ldots\ldots + x_{520} \geq 2$$

$$x_{61} + x_{62} + x_{63} + x_{64} + x_{65} + \ldots\ldots\ldots\ldots + x_{620} \geq 2$$

$$x_{91} + x_{92} + x_{93} + x_{94} + x_{95} + \ldots\ldots\ldots\ldots + x_{920} \geq 2$$

$$x_{131} + x_{132} + x_{133} + x_{134} + x_{135} + \ldots\ldots\ldots\ldots + x_{1320} \geq 2$$

$$x_{141} + x_{142} + x_{143} + x_{144} + x_{145} + \ldots\ldots\ldots\ldots + x_{1420} \geq 2$$

$$x_{161} + x_{162} + x_{163} + x_{164} + x_{165} + \ldots\ldots\ldots\ldots + x_{1620} \geq 2$$

$$x_{181} + x_{182} + x_{183} + x_{184} + x_{185} + \ldots\ldots\ldots\ldots + x_{1820} \geq 2$$

$$x_{201} + x_{202} + x_{203} + x_{204} + x_{205} + \ldots\ldots\ldots\ldots + x_{2020} \geq 2$$

$$x_{241} + x_{242} + x_{243} + x_{244} + x_{245} + \ldots\ldots\ldots\ldots + x_{2420} \geq 2$$

$$x_{261} + x_{262} + x_{263} + x_{264} + x_{265} + \ldots\ldots\ldots\ldots + x_{2620} \geq 2$$

$$x_{291} + x_{292} + x_{293} + x_{294} + x_{295} + \ldots\ldots\ldots\ldots + x_{2920} \geq 2$$

$$x_{311} + x_{312} + x_{313} + x_{314} + x_{315} + \ldots\ldots\ldots\ldots + x_{3120} \geq 2$$

$$x_{321} + x_{322} + x_{323} + x_{324} + x_{325} + \ldots\ldots\ldots\ldots + x_{3220} \geq 2$$

$$x_{331} + x_{332} + x_{333} + x_{334} + x_{335} + \ldots\ldots\ldots\ldots + x_{3320} \geq 2$$

$$x_{341} + x_{342} + x_{343} + x_{344} + x_{345} + \ldots\ldots\ldots\ldots + x_{3420} \geq 2$$

$$x_{351} + x_{352} + x_{353} + x_{354} + x_{355} + \ldots\ldots\ldots\ldots + x_{3520} \geq 2$$

$$x_{361} + x_{362} + x_{363} + x_{364} + x_{365} + \ldots\ldots\ldots\ldots + x_{3620} \geq 2$$

$$x_{371} + x_{372} + x_{373} + x_{374} + x_{375} + \ldots\ldots\ldots\ldots + x_{3720} \geq 2$$

$$x_{381} + x_{382} + x_{383} + x_{384} + x_{385} + \ldots\ldots\ldots\ldots + x_{3820} \geq 2$$

$$x_{401} + x_{402} + x_{403} + x_{404} + x_{405} + \ldots\ldots\ldots\ldots + x_{4020} \geq 2$$

$$x_{411} + x_{412} + x_{413} + x_{414} + x_{415} + \ldots\ldots\ldots\ldots + x_{4120} \geq 2$$

$$x_{421} + x_{422} + x_{423} + x_{424} + x_{425} + \ldots\ldots\ldots\ldots + x_{4220} \geq 2$$

$$x_{431} + x_{432} + x_{433} + x_{434} + x_{435} + \ldots\ldots\ldots\ldots + x_{4320} \geq 2$$

$$x_{441} + x_{442} + x_{443} + x_{444} + x_{445} + \ldots\ldots\ldots\ldots + x_{4420} \geq 2$$

$$x_{451} + x_{452} + x_{453} + x_{454} + x_{455} + \ldots\ldots\ldots\ldots + x_{4520} \geq 2$$

$$x_{461} + x_{462} + x_{463} + x_{464} + x_{465} + \ldots\ldots\ldots\ldots + x_{4620} \geq 2$$

$$x_{471} + x_{472} + x_{473} + x_{474} + x_{475} + \ldots\ldots\ldots\ldots + x_{4720} \geq 2$$

$$x_{481} + x_{482} + x_{483} + x_{484} + x_{485} + \ldots\ldots\ldots\ldots + x_{4820} \geq 2$$

$$x_{491} + x_{492} + x_{493} + x_{494} + x_{495} + \ldots\ldots\ldots\ldots + x_{4920} \geq 2$$

$$x_{501} + x_{502} + x_{503} + x_{504} + x_{505} + \ldots\ldots\ldots\ldots + x_{5020} \geq 2$$

$$x_{511} + x_{512} + x_{513} + x_{514} + x_{515} + \ldots\ldots\ldots\ldots + x_{5120} \geq 2$$

$$x_{531} + x_{532} + x_{533} + x_{534} + x_{535} + \ldots\ldots\ldots\ldots + x_{5320} \geq 2$$

$$x_{541} + x_{542} + x_{543} + x_{544} + x_{545} + \ldots\ldots\ldots\ldots + x_{5420} \geq 2$$