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Allocation of Faculty Supervisors for Industrial and Research Training

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Abstract
This study addresses the challenge of allocating supervisors to students undergoing industrial and research training programs in the Faculty of Science at Universiti Teknologi Malaysia (UTM) Johor Bahru. A mathematical model for supervisor-student allocation is proposed to enhance the efficiency and effectiveness of the allocation process. The model utilizes binary integer linear programming and maximizes the preference score of supervisor-student pairs based on location and program. The model ensures each student is assigned to only one supervisor and limits the number of students per supervisor based on their capacity. The study utilizes Excel OpenSolver as the solving tool and presents consistent and robust allocation results. The model successfully balances workload distribution, constraint satisfaction, and preference fulfillment. The discussion emphasizes the model's adaptability to diverse criteria and suggests future research directions, including exploring additional allocation factors, incorporating real-time data, and considering stakeholder perspectives. The findings demonstrate the model's consistent optimization of preference satisfaction while considering constraints. Overall, the proposed allocation model offers an efficient solution to the supervisor-student allocation problem in training programs.

Keywords: Supervisor-student Allocation; Binary Integer Linear Programming; Preference Score.

1. Introduction

Resource allocation is a crucial process for organizations to effectively manage their resources and align them with strategic goals (Lutkevich & Lebeaux, 2022). It involves optimizing the utilization of tangible assets like hardware and intangible assets such as human capital. The objective of resource allocation is to maximize the use of limited resources and achieve the highest return on investment by balancing competing requirements and priorities. In the context of the supervisor-student allocation for industrial and research training programs, strategic resource allocation can lead to cost reduction, increased productivity, and improved satisfaction among lecturers (Rastogi, 2022).

Universiti Teknologi Malaysia (UTM) Johor Bahru is among the universities that make internship training programs mandatory for undergraduate students. While the university administration can handle the allocation of supervisor-students for industrial and research training, implementing a systematic approach would be beneficial (Rastogi, 2022). Various studies have been conducted on the topic of supervisor-student allocation, offering insights and different approaches to solving the problem.

For example, Şimşek (2022) proposed a multi-objective binary model and a decision support tool for supervisor-student allocation in postgraduate education. Sanchez-Anguix et al. (2019) used a multi-objective genetic and Pareto optimal approach, considering the preferences of both supervisors and students, as well as workload balancing. Salami et al. (2016) employed a genetic algorithm (GA) that prioritized students' preferences over supervisors'. Ramotsisi et al. (2022) developed an integer linear programming model for optimizing student-to-project supervisor assignment, demonstrating its practical application in a mechanical engineering department.

These studies highlight the variety of approaches and considerations involved in allocating supervisors to students for industrial and research training programs. However, there is a need for a mathematical model specifically tailored to the supervisor-student allocation process at UTM Johor Bahru's Faculty of Science. Such a model would optimize the allocation process and consider factors such as program and training location, compatibility of supervisor and student preferences, and supervision load.

The research objectives of this study are twofold: a) To develop an optimal supervisor-student allocation model through binary integer linear programming. b) To analyze various situations related to the allocation of supervisors and students for industry and research training programs.

The scope of the study is limited to solving the allocation problem for supervisor-student pairs in the industrial and research training program at UTM Johor Bahru's Faculty of Science. The parameters observed include program and training location, compatibility of preferences, and supervision load. The study will provide valuable insights and a systematic approach for the university administration, leading to more efficient and optimal supervisor-student allocations.

This study's significance lies in its contribution to the existing body of research on supervisor-student allocation. It serves as a guide for researchers interested in addressing similar allocation problems and offers practical benefits to university administrations. By adopting a systematic approach to allocation, universities can streamline the process, reduce costs, and enhance overall efficiency.

The thesis is organized as follows: Chapter 2 provides a comprehensive literature review on the allocation of faculty supervisors for industrial and research training, establishing a theoretical foundation for the study. Chapter 3 describes the research methodology, including the problem formulation and the construction of a binary integer linear programming model. Chapter 4 presents the results and analysis of the supervisor-student allocation in different situations. Finally, Chapter 5 concludes the research and offers recommendations for future work in this field.

2. Literature Review

I have conducted a thorough literature review on the topic of faculty supervisors' allocation for industrial and research training. The process of resource allocation has been defined as the assignment and management of assets to achieve organizational objectives. This includes tangible assets like hardware and intangible assets such as human capital. It is crucial to balance priorities and demands in order to optimize limited resources and maximize return on investment (Techtarget, 2022).

Efficient resource allocation brings numerous benefits to an organization. It promotes enhanced collaboration, increased efficiency, improved team morale, and cost reduction. Effective communication and collaboration between teams are facilitated, ensuring optimal resource utilization. Distributing responsibilities fairly among employees boosts their morale, while cost savings are achieved by improving efficiency and avoiding errors and delays (Techtarget, 2022). Additionally, resource allocation contributes to improved employee retention, aids in planning, promotes transparency, and facilitates better time management (Kashyap, 2022).

However, resource allocation encounters challenge due to evolving project scopes, market fluctuations, and communication gaps between departments. Inaccurate forecasting of product demand can lead to mismatches between capacity and demand, affecting resource allocation. Under-allocation and overallocation of resources can have negative consequences, such as decreased productivity, lower output quality, burnout, and excess inventory. To mitigate these challenges, it is important to adapt to changes, enhance communication, and maintain a balanced relationship between capacity and demand (Rastogi, 2022).

Regarding supervisor-student allocation, several studies have addressed this issue in educational contexts. For example, Şimşek (2022) proposes a multi-objective binary model and a user-friendly decision support tool for allocating students to supervisors in postgraduate education. The model combines different allocation approaches and allows for a trade-off parameter to achieve a balanced outcome. Salami et al. (2016) and Hussain et al. (2019) both propose genetic algorithm approaches for allocating project supervisors to students based on their preferences and workload constraints. These studies demonstrate the effectiveness of the genetic algorithm in producing satisfactory allocations and generating multiple solutions for discussion.

Ramotsisi *et al.* (2022) focus on optimizing student-to-project supervisor assignments in an engineering department using an integer linear programming model. The researchers validate the model using real data and introduce a standardized measurement tool to minimize mismatches between student and supervisor preferences. In Sanchez *et al.* (2019), a multi-objective genetic approach is proposed for student-supervisor allocation. The approach effectively handles multiple objectives and considers both student and lecturer preferences without requiring explicit student preferences. The authors introduce problem-specific genetic algorithm operators and innovative crossover operators to improve the allocation process.

In summary, the literature review reveals the importance of resource allocation in the context of supervisor-student allocation for industrial and research training. It emphasizes the benefits of efficient resource allocation, such as enhanced collaboration, increased efficiency, improved team morale, and cost reduction. The challenges faced in resource allocation include evolving project scopes, market fluctuations, and communication gaps between departments. The studies on supervisor-student allocation provide valuable insights into different approaches, including mathematical models and tools, to optimize the allocation process. These approaches consider student preferences, workload limitations, and department constraints to achieve balanced and efficient allocations. The literature review serves as a solid foundation for the subsequent discussion of the methodology adopted in the study.

3. Research Methodology

Chapter 3 introduces the methodology for the research, including the research framework, model formulation, and solution method. The research framework is illustrated in Figure 3.1, starting with a literature review and problem formulation. The focus of the study is on allocating supervisor-student pairs for industry and research training using a binary integer linear programming model. Computational experiments will be conducted to validate the proposed solution, utilizing collected data and solving the model optimally with Excel Open Solver.

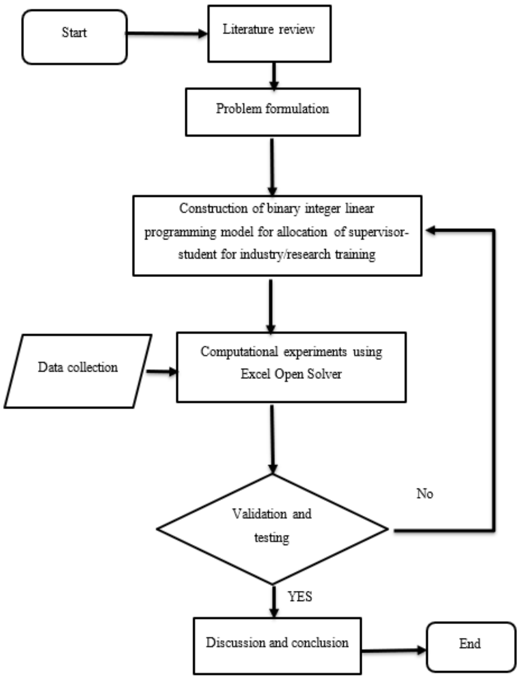

Figure 1 Research framework.

The literature review and problem formulation involved reviewing published articles related to supervisor-student allocation, narrowing down the research problem to the allocation process in industry and research training programs. The review provided insights into existing studies and academic journals, serving as a basis for the study's main ideas and contents.

The model formulation is presented below. First is the sets and parameters used, including the capacity of supervisors, the total number of students and supervisors, and preference scores based on location and program. then we introduce the decision variable for this study, which is a binary variable indicating whether a student is assigned to a supervisor. The objective function equation aim is to maximize the total preference score of allocated supervisor-student pairs, with a higher weight given to location preference. We have also outlined the constraints used, ensuring that each student is assigned to only one supervisor, supervisors are not overburdened, and the decision variable takes binary values.

Set and parameters:

S_j: the capacity of supervisor i.e., the maximum number of students that supervisor can take under them.
n: the total number of students.
m: the total number of supervisors.
L_{ij}: preference score based on location for supervisor j to student i
P_{ij}: preference score based on program for supervisor j to student i

Decision variables:

X_{ij}: binary variable that indicates whether student i is assigned to supervisor j.
X_{ij} = 1, if student i is assigned to supervisor j.
X_{ij} = 0, otherwise.

Objective function equation:

Maximize $\sum_{i=1}^{n}\sum_{j=1}^{m}(P_{ij} + 2L_{ij}) \cdot X_{ij}$

Constraints:

$\sum_{i=1}^{n} X_{ij} = 1$

$\sum_{j=1}^{m} X_{ij} \leq Sj$ for all i

X_{ij} belong to (0,1) for all i and j

Data collection for the study involves obtaining information on the location and academic program of students and supervisors from the Faculty of Science at Universiti Teknologi Malaysia (UTM) Johor Bahru, along with supervisors' location preferences.

Computational experiments will be conducted using Excel Open Solver, a tool integrated with Excel that provides optimization capabilities. Open Solver will solve the supervisor-student allocation problem, considering preferences and constraints to find the best allocation solution.

4. Result and Discussion

In the following discussion, I analyzed the allocation process and evaluated the performance of our model in four different situations. Each situation had a specific objective, ranging from minimizing supervisor workload to maximizing supervisor capacity and considering location and program preferences for better matching.

In Situation 1, our goal was to minimize the workload for supervisors while ensuring an even distribution of students. We set a maximum workload of 4 students per supervisor. The allocation results showed that some supervisors were not assigned any students, but we achieved a maximum preference score of 782.4, indicating a favorable allocation outcome.

Moving on to Situation 2, our objective was still workload minimization, but this time we wanted to ensure that each supervisor was assigned at least one student. To meet this requirement, we incorporated an additional constraint into the model. The allocation results showed that all supervisors were assigned at least one student, and the maximum preference score remained the same as in Situation 1.

Additional constraint:
$\sum_{j=1}^{m} xij \geq 1$

In In Situation 3, we shifted our focus to maximizing the capacity of supervisors without overburdening them. We aimed to allocate students in a way that maximized the workload for each supervisor without exceeding a limit of 10 students per supervisor. This objective allowed us to optimize supervisor capacity while maintaining a manageable workload.

Situation 4 we want to maximize the capacity of supervisors without overburdening them, but with the additional constraint of ensuring that each supervisor was assigned at least one student. The goal here was to strike a balance between maximizing supervisor capacity and maintaining a reasonable workload. The allocation results demonstrated the decisions made by our model based on these objectives and constraints.

Our allocation process relied on data obtained from the Faculty of Science at Universiti Teknologi Malaysia. This data included information about the students' academic programs, the location of industry and research training, and the program and location preferences of the supervisors. By categorizing the data, we were able to facilitate better matching between students and supervisors based on program categories and training locations.

To prioritize and guide the allocation process, we calculated preference scores. These scores were based on location preferences, program preferences, and a combination of both. We presented tables illustrating the preference scores for different location and program combinations, allowing us to evaluate and assign preference scores to supervisor-student pairs.

Table 5: Preference score of supervisor-student based on location

			1	2	3	4	5	6	7	8	9	10	11
			ABDUL FA	ADIBAH BI	ALINA BIN	AZMAN BI	CHONG CH	FAEZAH BI	FAHRUL ZA	FAZILAH B	GOH KIAN	HARYATI B	HUSZALINA
			PAHANG	MELAKA	PERAK	PERLIS	PERAK	JOHOR	NEGERI SE	TERENGGA	NEGERI SE	NEGERI SE	PAHANG
1	A19SC0067	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
2	A18SC0466	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
3	A17MB0143	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
4	A19SC0079	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
5	A18SC0401	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
6	A19SC0144	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
7	A19SC0424	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
8	A19SC0125	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
9	A19SC0151	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
10	A19SC0398	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
11	A19SC0127	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
12	A19SC0394	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
13	A19SC0412	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
14	A19SC0014	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
15	A19SC0168	JOHOR	0.3	0.7	0.3	0.3	0.3	1	0.7	0.3	0.7	0.7	0.3
16	A19SC0203	ELANTAN	0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.7	0.3	0.3	0.7
17	A19SC0025	MELAKA	0.3	1	0.3	0.3	0.3	0.7	0.7	0.3	0.7	0.7	0.3
18	A19SC0056	MELAKA	0.3	1	0.3	0.3	0.3	0.7	0.7	0.3	0.7	0.7	0.3
19	A19SC0094	MELAKA	0.3	1	0.3	0.3	0.3	0.7	0.7	0.3	0.7	0.7	0.3

Table 6: Preference score of supervisor-student based on program

			1	2	3	4	5	6	7	8	9	10	11
			ABDUL FA	ADIBAH BI	ALINA BIN	AZMAN BI	CHONG CH	FAEZAH BI	FAHRUL ZA	FAZILAH B	GOH KIAN	HARYATI B	HUSZALINA
			BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO
1	A19SC0067	BIO	1	1	1	1	1	1	1	1	1	1	1
2	A18SC0466	BIO	1	1	1	1	1	1	1	1	1	1	1
3	A17MB0143	BIO	1	1	1	1	1	1	1	1	1	1	1
4	A19SC0079	BIO	1	1	1	1	1	1	1	1	1	1	1
5	A18SC0401	BIO	1	1	1	1	1	1	1	1	1	1	1
6	A19SC0144	BIO	1	1	1	1	1	1	1	1	1	1	1
7	A19SC0424	BIO	1	1	1	1	1	1	1	1	1	1	1
8	A19SC0125	BIO	1	1	1	1	1	1	1	1	1	1	1
9	A19SC0151	BIO	1	1	1	1	1	1	1	1	1	1	1
10	A19SC0398	BIO	1	1	1	1	1	1	1	1	1	1	1
11	A19SC0127	BIO	1	1	1	1	1	1	1	1	1	1	1
12	A19SC0394	BIO	1	1	1	1	1	1	1	1	1	1	1
13	A19SC0412	BIO	1	1	1	1	1	1	1	1	1	1	1
14	A19SC0014	BIO	1	1	1	1	1	1	1	1	1	1	1
15	A19SC0168	BIO	1	1	1	1	1	1	1	1	1	1	1
16	A19SC0203	BIO	1	1	1	1	1	1	1	1	1	1	1
17	A19SC0025	BIO	1	1	1	1	1	1	1	1	1	1	1
18	A19SC0056	BIO	1	1	1	1	1	1	1	1	1	1	1
19	A19SC0094	BIO	1	1	1	1	1	1	1	1	1	1	1

Table 7: Preference score based on location and program

		1	2	3	4	5	6	7	8	9	10	11
		ABDUL FA	ADIBAH BI	ALINA BIN	AZMAN BI	CHONG CH	FAEZAH BI	FAHRUL ZA	FAZILAH B	GOH KIAN	HARYATI B	HUSZALIN
1	A19SC0067	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2	A18SC0466	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
3	A17MB0143	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
4	A19SC0079	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
5	A18SC0401	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
6	A19SC0144	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
7	A19SC0424	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
8	A19SC0125	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
9	A19SC0151	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
10	A19SC0398	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
11	A19SC0127	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
12	A19SC0394	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
13	A19SC0412	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
14	A19SC0014	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
15	A19SC0168	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
16	A19SC0203	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6

The allocation results were obtained using Excel Solver, which utilized the objective function model and specific constraints for each situation. We adjusted the solver parameters accordingly to optimize the allocation based on the given objectives and constraints.

In summary, our discussion provided a comprehensive overview of the allocation process, the data used, the calculation of preference scores, and the allocation results for each situation. It demonstrated the effectiveness of our model in achieving the desired objectives and constraints in supervisor-student allocation.

Conclusion and Recommendation

In conclusion, I have successfully addressed the problem of supervisor-student allocation for the industrial and research training program at UTM Johor Bahru's Faculty of Science. Through extensive research and analysis, I have developed a mathematical model that takes into account various factors and preferences to efficiently allocate supervisors to students. The model has been validated through computational experiments and has demonstrated its effectiveness in handling different allocation situations while optimizing costs and increasing efficiency and satisfaction among supervisors and students.

Moving forward, I would like to propose some recommendations for future research in this area. Firstly, it would be beneficial to incorporate additional preferences such as industry sectors, language proficiency, and familiarity with the industry into the allocation model. By considering a broader range of preferences, we can enhance the allocation process and ensure the satisfaction of both supervisors and students.

Furthermore, I believe that exploring dynamic allocation models would be valuable. The current model assumes a static allocation process, but in reality, the availability and workload of supervisors may change over time. By developing dynamic allocation models that can adapt to changing circumstances, we can ensure efficient allocation even in dynamic environments.

Another important aspect to consider is the compatibility between supervisors and students. While the current model accounts for location and program preferences, it does not explicitly address compatibility factors such as communication style, mentoring approach, or personality traits. Incorporating these factors into the allocation process would lead to better supervisor-student matches and improve overall outcomes.

Additionally, I would recommend integrating machine learning techniques into the allocation process. By applying clustering algorithms or recommendation systems to analyze historical allocation data, we can identify patterns or preferences that are not explicitly captured in the current model. This integration of machine learning could lead to more accurate predictions and better-informed decision-making.

Furthermore, it would be valuable to compare the performance of different allocation methods, such as genetic algorithms, metaheuristic algorithms, or machine learning-based approaches. By conducting such a comparison, we can determine the most effective allocation method in the context of supervisor-student allocation.

To gain a better understanding of the impact of the allocation process, I suggest evaluating its effects on students' academic and professional development. This could be done through surveys or interviews to gather feedback on the effectiveness of the allocated supervisors, the quality of supervision received, and the overall satisfaction with the allocation outcome.

Lastly, it would be interesting to investigate the generalizability of the model beyond the Faculty of Science at UTM Johor Bahru. By applying the developed model to other faculties or universities and assessing its effectiveness in different educational contexts, we can determine its applicability in various settings.

By considering these recommendations in future research endeavors, we can further enhance our understanding of supervisor-student allocation and its impact. This will contribute to the development of more sophisticated and comprehensive allocation strategies that can be implemented in various educational and training programs, ultimately improving the overall educational experience for students.

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