Universiti Teknologi MARA

I-URIID 2025

INTERNATIONAL UNDERGRADUATE RESEARCH INNOVATION, INVENTION AND DESIGN

UNDERGRADUATES PIONEERING TOMORROW'S BREAKTHROUGH

E-BOOK OF EXTENDED ABSTRACTS

AN INTEGER LINEAR PROGRAMMING APPROACH TO TEACHING LOAD ALLOCATION

Nur Farhan Izarine Afizan, and Nurul Liyana Abdul Aziz*

Fakulti Sains Komputer dan Matematik, Universiti Teknologi MARA Cawangan Negeri Sembilan, Kampus Seremban, 70300 Seremban, Negeri Sembilan, Malaysia

*liyana511@uitm.edu.my

ABSTRACT

Teaching Load Allocation (TLA) problem is a common operational challenge in higher education institutions, where aligning lecturer expertise with course demands while balancing workloads remains complex. Traditionally, TLA at Mathematics Department in Faculty of Computer and Mathematical Sciences, UiTM Seremban, has been conducted manually by the timetabling committee, often leading to issues such as workload imbalance, mismatched subject expertise, and inefficient resource allocation. This study aims to address these challenges by proposing a mathematical optimisation model using Integer Linear Programming (ILP) to systematically assign lecturers to student groups based on courses and lecture hours. The model was applied to consider the maximum teaching hours, and the need to consolidate small student groups. A real dataset comprising 19 courses, 92 student groups, and 25 lecturers was used. The results demonstrate that the ILP model effectively maximises the utilisation of lecturer teaching hours while adhering to all defined constraints. This approach provides a practical and systematic alternative to manual scheduling, enhancing resource allocation and contributing to better academic planning.

Keywords: Teaching Load Allocation (TLA), Integer Linear Programming (ILP), Microsoft Excel Solver

INTRODUCTION

In Faculty of Computer and Mathematical Sciences (FSKM) at UiTM Kampus Seremban, TLA is solved manually by timetable committee which is assigned by the head of department in a month before the student starts to register their courses. Even though TLA is solved manually, the decision makers must consider several parameters before proceeding with the scheduling. First, lecturers have different fields of specialty, and it is important to match the requirements for a subject to be taught effectively (Caselli et al., 2022). Second, lecturers should be assigned based on their maximum number of teaching hours to prevent burning out and ensure they have sufficient time to prepare and deliver content effectively to students. Third, a small number of students in a group should be combined to prevent excessive teaching hours. In general, scheduling TLA needs to be balanced with all aspects to create a better teaching and learning environment. However, TLA will usually change due to the dynamic environment, like the number of educators may change unexpectedly, the number of students in a group may increase which need additional lecturers (Caselli et al., 2022).

This study points out the inefficiencies in manual TLA by proposing an Integer Linear Programming (ILP) model. The ILP model is designed to optimize the TLA by incorporating a set of constraints. The production of an effective TLA, scheduling decisions can be made more systematically and effectively, ensuring compliance with academic standards and easing the workload for the lecturer in charge. ILP is an extension of LP by limiting the choice variables to integers. This approach is useful for assignment problems when there are only two possible outcomes: either a lecturer is assigned to a course, or they are not. Algethami and Laesanklang (2021) used ILP to schedule courses, considering the lecturer's credentials and time restrictions.

The data of 25 Mathematics lecturers in Faculty of Computer and Mathematical Sciences in UiTM Kampus Seremban were taken from the timetable committee contain of number of lecturers, lecture hour, list of courses and student groups per course. Table 1 shows the list of courses with lecture hour and student groups while Table 2 presents the list of lecturers with limit of student groups and lecture hour.

Table 1: List of courses with lecture hour and student groups

Course code	Lecture hour	Student group
K1	4	G1 – G4
K2	4	G5 – G9
K3	4	G10 – G11
K4	4	G12 – G15
K5	5	G16 – G17
K6	5	G18 – G26
K7	4	G27 – G30
K8	4	G31 – G36
K9	4	G37 – G43
K10	4	G44 – G50
K11	4	G51 – G54
K12	4	G55 – G56
K13	4	G57 – G59
K14	4	G60 – G61
K15	4	G62 – G64
K16	4	G65 – G67
K17	4	G67 – G72
K18	4	G73 – G84
K19	4	G85 – G92

Table 2: List of lecturers with limit of student groups and lecture hour

Lecturer	Limit student group	Limit lecture hour
L1	4	16
L2	4	16
L3	4	16
L4	4	18
L5	4	18
L6	4	16
L7	4	16
L8	4	16

L9	4	18
L10	4	16
L11	4	16
L12	4	18
L13	4	16
L14	1	4
L15	4	16
L16	2	8
L17	4	18
L18	4	16
L19	4	16
L20	4	16
L21	4	16
L22	4	16
L23	4	18
L24	4	18
L25	4	16

ILP FORMULATION

This study utilizes an ILP model to maximize the total number of lecture hours assigned to lecturers while considering a set of constraints to balance the workloads.

Notation

Set of student groups (Gi) : $\{G1, G2, \dots, G92\}$
Set of lecturers (Lj) : $\{L1, L2, \dots, L25\}$
Lecture hour for each student group (K_{Gi}) : $\{K_{G1} = 4, K_{G2} = 4, \dots, K_{G92} = 4\}$
Limit student group for each lecturer (N_{Lj}) : $\{N_{L1} = 4, N_{L2} = 4, \dots, N_{L25} = 4\}$
Limit lecture hour for each lecturer (M_{Lj}) : $\{M_{L1} = 16, M_{L2} = 16, \dots, M_{L25} = 16\}$

Decision variable, $X_{Gi,Lj} = \begin{cases} 1, & if\ a\ student\ group\ Gi\ is\ aasigned\ to\ a\ lecturer\ Lj \\ 0, & otherwise \end{cases}$

Objective function

$$\text{Max } Z = \sum K_{Gi}\, X_{Gi,Lj} \tag{1}$$

Subject to

Constraint 1: Each student group must be assigned to a lecturer

$$\sum X_{Gi,Lj} = 1 \qquad \forall Gi \tag{2}$$

Constraint 2 : Limit student group for each lecturer

$$\sum X_{Gi,Lj} \leq N \qquad \forall Lj \qquad (3)$$

Constraint 3 : Limit lecture hour for each lecturer

$$\sum K_{Gi} X_{Gi,Lj} \leq M \qquad \forall Lj \qquad (4)$$

RESULTS AND DISCUSSION

Table 3 the output of ILP solution using Microsoft Excel Solver that assigns lecturers to specific student groups for various courses. Most lecturers have 16 to 18 lecture hours, which satisfy Constraint 2 which is the limit of lecture hour. L16 which involves in administration post in faculty only assigned to 2 student groups with a total of 8 lecture hours. The same goes to L14 with 1 student group (4 hours) assigned. The course allocation results indicate that some lecturers are assigned to multiple student groups within the same course, which promotes continuity in content delivery and efficient scheduling. Additionally, most lecturers are responsible for teaching more than one course, reflecting a balanced distribution of workload and optimal use of teaching resources across the curriculum.

CONCLUSION

Overall, the findings clearly demonstrated that the model could maximise the total teaching hours, while the constraints were respected. The assignments of lecturers were appropriate for their expertise level, and the workloads were fairly distributed. Microsoft Excel Solver was a very interesting example of a tool that can be used in institutional settings to tackle optimisation issues, especially where institutions may not have invested in additional money to purchase advanced software to solve optimization issues.

In conclusion, this study illustrated how utilizing an ILP model can revolutionise academic administration. The ILP model provided not only a systematic, transparent, and effective alternative to traditional scheduling approaches, but it was also much less time consuming. The quality of TLA assignments produced was also significantly improved over previous methods mentioned in the literature review.

Table 3: Output teaching load for each lecturer

Lecturer	**Course-student group**	**Lecture hour**	**Lecturer**	**Course-student group**	**Lecture hour**
L1	K7: G29 K10: G48-G50	16	L14	K18: G71	4
L2	K12: G55 K16: G65 – G67	16	L15	K7: G30 K8: G31 – G33	16
L3	K12: G56 K13: G57 – G59	16	L16	K8: G34 – G35	8
L4	K19: G76 K20: G86 – G88	16	L17	K4: G13 – G14 K9: G16 – G17	18
L5	K1: G1 K4: G15 K6: G22 – G23	18	L18	K8: G36 K9: G37 – G39	16
L6	K14: G60 – G61 K15: G62 – G63	16	L19	K15: G64 K18: G72 K19: G74 – G75	16

L7	K19: G77 – G80	16	L20	K9: G40 – G43	16
L8	K1: G2 – G4 K2: G5	16	L21	K10: G44 – G47	16
L9	K2: G6 – G8 K6: G20	17	L22	K11: G51 – G54	16
L10	K19: G81 – G84	16	L23	K2: G9 K3: G10 K6: G18 – G19	18
L11	K18: G68 – G70 K19: G73	16	L24	K6:G25 – G26 K7: G27 – G28	18
L12	K3: G11 K4: G12 K6: G21, G24	18	L25	K20: G89 – G92	16
L13	K20: G85	4			

REFERENCES

Algethami, H., & Laesanklang, W. (2021). A mathematical model for course timetabling problem with faculty-course assignment constraints. *IEEE Access*, *9*, 111666 – 111682. https://doi.org/10.1109/ACCESS.2021.3103495

Caselli, G., Delorme, M., & Iori, M. (2022). Integer Linear Programming for the Tutor Allocation Problem: A practical case in a British University. *Expert Systems with Applications*, *187*. https://doi.org/10.1016/j.eswa.2021.115