

Optimizing lecturer-course assignment in UiTM Seremban using the Modified Hungarian Method for academic competency enhancement

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ABSTRACT Efficient allocation of lecturers to courses is essential for maintaining teaching standards and lecturer satisfaction within higher education. Although the traditional Hungarian Method has frequently been applied in earlier research, its modified version (MHM) has yet to be extensively examined in the context of competency-based lecturer assignments. This study introduces an optimized model for assigning lecturers to courses at UiTM Seremban, embedding multidimensional competency factors into enhanced mathematical formulation. As an applied optimization approach, this study integrates lecturers' knowledge, skills, and teaching motivation into the MHM framework to maximize overall competency scores in course assignments. Competency data were collected through an online survey from Mathematics lecturers at UiTM Seremban, serving as the core empirical input for the optimization model. MATLAB's intlinprog solver was utilized to execute the model, promoting a well-balanced and effective teaching assignment structure where lecturers are allocated up to three courses based on their optimal competency profiles. The results highlight the high effectiveness of this applied MHM framework in aligning course assignments with lecturers' precise expertise, effectively minimizing academic mismatches and improving overall education quality. This study contributes to the field of educational optimization by demonstrating a novel application of the MHM framework, offering a highly structured and scalable approach to enhance academic performance and faculty resource management.

KEYWORDS: Competency; Tertiary Institutions; Lecturers-to-Courses Assignment; Modified Hungarian Method; Mathematical Programming Model

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INTRODUCTION

Strategic lecturer-to-course assignment is crucial for maximizing instructional quality and student outcomes (Hölzer *et al.*, 2017). At UiTM Seremban, the Mathematics faculty exhibits diverse expertise, necessitating a systematic allocation mechanism based on holistic competencies: knowledge, skills, and teaching motivation. However, traditional scheduling frequently relies on superficial heuristics, overlooking these multidimensional pillars. While the traditional Hungarian Method (HM) is a foundational combinatorial optimization algorithm widely adopted for assignment problems (Kuhn 1955; Chowdhury 2022), it strictly assumes a balanced ($n \times n$) matrix. In real-world academic management, lecturer-to-course ratios are inherently asymmetrical. To surmount this, the Modified Hungarian Method (MHM) is required to accommodate unbalanced configurations (Ibrahim *et al.*, 2024).

Existing HM-based allocation studies typically evaluate competency through a narrow, single-metric lens. Furthermore, it is necessary to explicitly distinguish this current work from the foundational unbalanced matrix model proposed by Ibrahim *et al.* (2024). While the 2024 study successfully established the baseline structural parameters for unbalanced allocations, it did not account for the complexities of pedagogical quality. To address this, the current study introduces an applied optimization framework that expands upon previous mathematical constraints. Specifically,

this paper introduces a multi-dimensional tripartite competency weighting system, integrating knowledge, skills and teaching motivation and incorporates dynamic workload bounds to restrict multi-course assignments. By executing this extended formulation via MATLAB's intlinprog solver, this study acts as a robust applied optimization approach rather than a new algorithmic invention, directly elevating institutional efficiency.

LITERATURE REVIEW

Strategic academic resource management relies heavily on aligning lecturer competencies with specific courses to ensure instructional quality. As demonstrated by Abdul Latip *et al.* (2020), faculty proficiency is a multidimensional construct that directly dictates student engagement and academic outcomes. Historically, academic optimization models have deployed the traditional Hungarian Method (HM) to solve these assignment challenges. Numerous studies have validated HM's ability to minimize preparation time, reduce administrative overhead, and improve teaching effectiveness across various educational settings (Kabiru *et al.*, 2017; Solaja *et al.*, 2020; Mallick *et al.*, 2021; Wattanasiripong & Sangwaranatee, 2021; Ahmed *et al.*, 2022; Udok & Victor-Edema, 2023). However, a major critique of these classic HM implementations is their strict reliance on a balanced, one-to-one mapping assumption ($n \times n$). This mathematical simplification fails to reflect actual higher education ecosystems, where faculty populations and course offerings are inherently asymmetrical.

To transcend these rigid mathematical constraints, the Modified Hungarian Method (MHM) was developed to resolve asymmetrical allocation challenges without sacrificing computational accuracy (Rabbani *et al.*, 2019). Yet, a stark literary paradox exists: while MHM is computationally robust, its empirical application has been heavily confined to non-educational domains. Recent literature has extensively deployed MHM architectures in areas such as structural preservation (Elsisy *et al.*, 2020), multi-agent spatial coordination (Zhang *et al.*, 2021), IoT and wireless networks (Liu *et al.*, 2021; Wei *et al.*, 2022), vehicular edge computing (Ge *et al.*, 2020) and 5G resource multicasting (Mukherjee & De, 2023). Despite its proven versatility in engineering and technology, MHM's adaptation within academic resource allocation remains fundamentally scarce.

The current literature highlights a critical research gap regarding the intersection of MHM formulations and competency-driven academic planning. While contemporary research has begun exploring multi-objective models to balance lecturer preferences with institutional needs (Ibrahim *et al.*, 2024), this study extends the unbalanced MHM structural parameters established by Ibrahim *et al.* (2024) by specifically applying it to competency-driven academic planning. By embedding multidimensional competency scores, mathematically integrating knowledge, skills and teaching motivation into an asymmetrical MHM framework, this model overcomes the limitations of traditional HM. Ultimately, this applied mathematical formulation provides a rigorous, highly scalable scheduling tool tailored specifically to optimize faculty deployment at the Mathematics Department of UiTM Seremban.

METHODOLOGY

During the first phase (March–August 2023), data was gathered via an online survey from 23 mathematics lecturers evaluating 20 undergraduate courses at UiTM Seremban. Using a standard Likert scale (Joshi *et al.*, 2015; South *et al.*, 2022), respondents self-rated three subjective attributes: knowledge, skills, and teaching motivation. A normalized score (x) for each lecturer was calculated by summing the ratings across these three elements and dividing by 12 (the maximum possible score), yielding a value between 0 and 1. This normalized value was mapped to a discrete competency

weight (1 to 4) using standard quartiles (0.0–0.25 = 1; 0.26–0.50 = 2; 0.51–0.75 = 3; 0.76–1.0 = 4). Transforming raw scores into ordinal quartiles is a validated psychometric technique to minimize subjective noise in Likert data (Ranstam & Cook, 2022). Furthermore, these linear weights mirror standard academic rubrics like the 4.0 GPA scale (Brookhart, 2013). Crucially, this discrete assignment prevents artificial skewing; it ensures the MATLAB solver's objective function prioritizes significant macro-level competency rather than being disproportionately swayed by marginal, statistically insignificant variances in raw scores (Joshi *et al.*, 2015). For context, a lecturer scoring 3 in each of the three elements yields $x = 9/12 = 0.75$ and is thus assigned $C = 3$).

In the second phase, these derived competency weights (C) were incorporated as coefficients within the MHM objective function. The expanded optimization matrices were structured in Microsoft Excel, and the final models were processed using MATLAB's `intlinprog` function to compute the optimal solutions. The ensuing formulation dictates the mathematical parameters of the model.

The Model for Mathematics Lecturers at UiTM Seremban

The mathematical formulation of the applied MHM framework is detailed below. This formulation constitutes a core structural variant designed specifically to optimize the deployment of academic faculty to relevant courses.

Model formulation

L : The complete set of lecturers, where $i \in L$ represents the lecturer index.

C : The complete set of courses, where $j \in C$ represents the course

S_{ij} : lecturer i competency to get course j

$X_{ij} = \begin{cases} 1, & \text{lecturer } i \text{ is assigned course } j \\ 0, & \text{otherwise} \end{cases}$

$$\text{Maximize } Z = \sum_{i \in L} \sum_{j \in C} S_{ij} X_{ij} \quad (1)$$

subject to

$$\sum_{j \in C} X_{ij} \geq 1, \quad \forall i \in L \quad (2)$$

$$\sum_{i \in L} X_{ij} \geq 1, \quad \forall j \in C \quad (3)$$

$$\sum_{j \in C} X_{ij} \leq 3, \quad \forall i \in L \quad (4)$$

$$\sum_{i \in L} X_{ij} \leq 3, \quad \forall j \in C \quad (5)$$

$$X_{ij} \in \{0, 1\}, \quad \forall i \in L, \forall j \in C \quad (6)$$

Model description

The mathematical programming model maximizes the cumulative competency index (Equation 1), ensuring courses are aligned with the most qualified faculty based on knowledge, skills and motivation. To guarantee real-world viability, the model is bound by essential structural constraints: Equations (2) and (3) enforce baseline coverage, requiring every lecturer to be allocated at least one course and every course to be assigned. To manage workload and co-teaching, Equations (4) and (5)

restrict lecturers to a maximum of three courses and limit any single course to at most three assigned lecturers. Equation (6) enforces binary integrality on the decision variables. These formulated parameters were expanded into matrices and subsequently solved using MATLAB's `intlinprog` function (Figure 1).

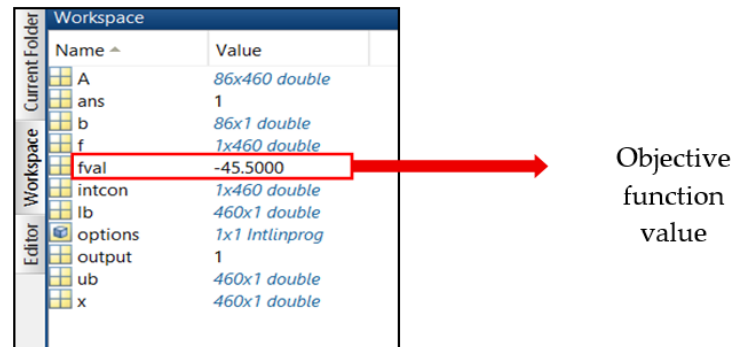


Figure 1. Workspace of MATLAB

Phase three, Computational Experiments, executed the model using MATLAB's `intlinprog` solver. The system was structured in a standard linear programming format: vector f denotes the objective function coefficients (using negative competency scores to represent maximization), while matrix A and right-hand side (RHS) vector b represent the inequality constraints. These Excel-based parameters were imported directly into MATLAB. The final phase systematically analyzed the solver outputs to evaluate the ACE-MHM model's allocation efficiency. Figure 1 illustrates these input matrices and vectors to ensure methodological reproducibility.

RESULT AND DISCUSSION

This section evaluates the optimization results of the competency-based MHM framework, executed via MATLAB's `intlinprog` solver. To maximize the competency index, the objective function was transformed to minimize the negative competency coefficients. The procedure converged successfully, yielding an optimal objective value (Z) of -45.5 which corresponds to maximum cumulative competency score of 45.5. The resulting binary decision variables ($X_{ij} \in \{0,1\}$) were translated into the final allocation matrix (Table 1). The results confirm that all predefined operational constraints were satisfied. Every course was assigned to qualified lecturers, capping at three instructors per course, while dynamically balancing faculty workloads based on competency scores. Highly specialized lecturers (S8, S12, S18, S20) were strategically assigned a single course, S5 received two and the remainder absorbed the maximum load of three courses. Furthermore, the model effectively captured pedagogical adaptability. Generalist faculty such as S1 and S4 were entrusted with courses spanning all three academic years. Conversely, specialists were focused appropriately: S6 and S16 exclusively handled foundational Year 1 courses while a distinct cohort (S3, S5, S13, S14, S15, S17, S22) managed advanced Year 2 and 3 modules. Ultimately, this data-informed strategy validates the applied MHM approach as a robust framework for optimal human capital deployment, maintaining academic quality and ensuring departmental sustainability.

Table 1. Optimal Lecturer-to-Course Assignment Plan Generated by the Applied MHM Framework

Lecturer Code	Assigned Courses	Lecturer Code	Assigned Courses
S1	MAT402, MAT571, MAT631	S13	MAT530, MAT633, MAT668
S2	MAT422, MAT571, MAT578	S14	MAT523, MAT530, MAT633
S3	MAT575, MAT583, MAT612	S15	MAT525, MAT571, MAT652
S4	MAT422, MAT583, MAT631	S16	MAT402, MAT423, MAT441
S5	MAT530, MAT668	S17	MAT578, MAT583, MAT612
S6	MAT421, MAT423, MAT441	S18	MAT578
S7	MAT491, MAT631, MAT652	S19	MAT422, MAT652, MAT633
S8	MAT668	S20	MAT522
S9	MAT421, MAT491, MAT560	S21	MAT441, MAT525, MAT560
S10	MAT402, MAT491, MAT523	S22	MAT522, MAT575, MAT612
S11	MAT423, MAT560, MAT575	S23	MAT421, MAT522, MAT523
S12	MAT525		

Note: [Year 1] **MAT402**: Business Mathematics; **MAT421**: Calculus I; **MAT422**: Mathematical Logic & Proving Techniques; **MAT423**: Linear Algebra I; **MAT441**: Calculus II; **MAT491**: Calculus III; **MAT522**: Ordinary Differential Equations. [Year 2] **MAT523**: Linear Algebra II; **MAT525**: Coding & Cryptography; **MAT530**: Intro to Mathematical Modelling; **MAT560**: Vector Calculus; **MAT571**: Real Analysis; **MAT575**: Intro to Numerical Analysis; **MAT578**: Mathematical Methods. [Year 3] **MAT583**: Applied Numerical Methods; **MAT612**: Partial Differential Equations; **MAT631**: Complex Analysis with Comp. Apps; **MAT633**: Fuzzy Set Theory; **MAT652**: Algebraic Structures; **MAT668**: Graph Theory with Applications.

CONCLUSION

This study successfully applied the Modified Hungarian Method (MHM) to address the specific complexities of competency-based lecturer-to-course allocations at UiTM Seremban. By maximizing cumulative competency scores, the model replaces conventional scheduling heuristics with a data-driven framework that ensures equitable workload distribution, comprehensive course coverage and precise alignment with faculty expertise. Ultimately, this applied optimization strategy provides a scalable blueprint for modern academic planning, safeguarding instructional rigor while promoting targeted professional development and faculty satisfaction. Future research should integrate real-time competency evaluations and dynamic constraints like fluctuating enrollments, varying credit-hours, and multi-campus synchronization to scale the model for larger institutions.

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