E-PROCEEDINGS

INTERNATIONAL TINKER INNOVATION & ENTREPRENEURSHIP CHALLENGE (i-TIEC 2025)

"Fostering a Culture of Innovation and Entrepreneurial Excellence"

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PTDI, UiTM Cawangan Johor Kampus Pasir Gudang

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A-ST031: LECTURERS TO COURSES STRUCTURED ASSIGNMENT BY ZONING BINARY INTEGER GOAL PROGRAMMING MODELS FEATURING ENHANCED MODIFIED HUNGARIAN METHOD (L-CSAZ BIGPE-MHM MODELS)

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ABSTRACT

Assignment problem mainly concerns with optimally allocating and assigning a number of n subjects with varying efficiencies to m jobs such that the total cost is minimized. This study addresses the lecturer-to-course (L-C) assignment problem, considering three aspects namely the lecturer preferences, competency levels and training needs. An enhanced Modified Hungarian Method (MHM) was employed to optimize lecturer allocation by identifying their Areas of Mathematics (AOM), a zoning approach. Subsequently. three multi-objective Binary Integer Goal Programming (BIGP) models were proposed, CT-BIGP (V1), which maximizes competency scores and minimizes training costs; CCPT-BIGP (V2), which maximizes combined competency and preference scores and minimizing training costs; and CPT-BIGP (V3), which maximizes competency scores, maximizes preference and minimizes training costs of lecturers. Data were collected through online surveys and interviews with Mathematics lecturers and academic administrators at Universiti Teknologi MARA (UiTM) Shah Alam and Seremban campuses. The courses included are Mathematics courses offered at these two campuses. MATLAB's intlinprog solver was used to solve the models. Results revealed that CCPT-BIGP (V2) is best suited for the L-C assignments at UiTM Shah Alam while CPT-BIGP (V3) performed best for UiTM Seremban. The models enable optimal L-C assignments, identify lecturers' upskilling needs and minimize training costs required for upskilling. Ultimately, the aim is to allow optimal L-C assignment by AOM, identify upskilling, improve lecturers' satisfaction and teaching quality, which contribute significantly to the university's academic excellence and institutional efficiency.

Keywords: Allocation and assignment problem; lecturer-to-course assignment; Modified Hungarian Method; Binary Integer Goal Programming; preferences, competency and training needs.

1. Product Description

The product is a novel optimization models designed to solve lecturer-to-course assignment problems in university. It combines the enhanced Modified Hungarian Method (MHM) with Multi-objective Binary Integer Goal Programming (BIGP) models to address key challenges in assigning courses to lecturers, addressing varying lecturers' preferences and competency levels. The framework includes three BIGP models, CT-BIGP (V1) which balances lecturer competency and training costs; CCPT-BIGP (V2) which integrates competency and preference scores while minimizing training costs; and CPT-BIGP (V3) which simultaneously maximizes competency, maximizes preferences, and minimizes training costs. By employing these models, academic institutions can achieve optimal lecturer allocation, identify Areas of Mathematics (AOM), attain effective lecturer-to-course assignment and determine training eds for upskilling. Models are validated and verified using data from Universiti Teknologi MARA (UiTM) where the models achieve maximizes the preferences and competency scores and minimizes the training costs for upskilling. The innovation offers universities a data-driven, cost-effective tool for better workload distribution and strategic lecturers' upskilling analysis by courses, ensuring academic excellence and institutional efficiency. This product is scalable to other education institutions and can be easily adopted and adapted for other assignment problems in various industries, making it a valuable asset for organization's management and planning.

2. Flow Charts of the Models and Tables of the Summary Results

Figure 1 shows the MHM and BIGP models where MHM models having five variants to get the areas of mathematics (AOM) while BIGP models having three variants. There are five variants for MHM model in this study as compared to the models in other past studies which only have one variant, that is either Preference or Competency. The first variant is the weightage method for the combination of Competency-Preference (CP) in which the objective function is formulated as a single objective, to maximize the CP. This variant of the modified MHM model is called the CP-MHM (V1) model. The second variant of the Modified MHM model of this study is a multi-objective MP model, where the first objective function is to maximize Preference (P) and the second objective function is to maximize Competency (C), thus named as the PCMO-MHM (V2) model. The preemptive GP approach was used to solve the PCMO-MHM model. The third variant of the Modified MHM model of this study is also a multi-objective MP model in which the first objective function is to maximize the Competency (C) and the second objective function is to maximize the Preference (P). This third variant model is called the CP MO-MHM (V3) model. The fourth and the fifth variants of the Modified MHM model of this study involves single objective function. The fourth variant of the Modified MHM model aims to maximize the Preference (P) only and is called the P-MHM (V4) model. Meanwhile, the fifth variant of the Modified MHM is to maximize Competency (C) only and called the C-MHM (V5) model. For BIGP models, the first variant is CT-BIGP model (Variant 1 or V1) that maximizes the total Competency (C) scores of lecturers for course assigned and minimizes the total training costs for lecturers' upskilling. Besides that, the second variant is CCPT-BIGP (V2) which maximizes the combined Competency (C) and Preference (P) scores of lecturers for the assigned courses and minimizes total training costs for lecturers' upskilling. Finally, the third variant is CPT-BIGP (V3) which maximizes the Competency (C) scores of lecturers for the assigned courses, maximizes the Preference (P) scores of lecturers for the courses assigned and minimizes the total training costs for lecturers' upskilling, in this order.

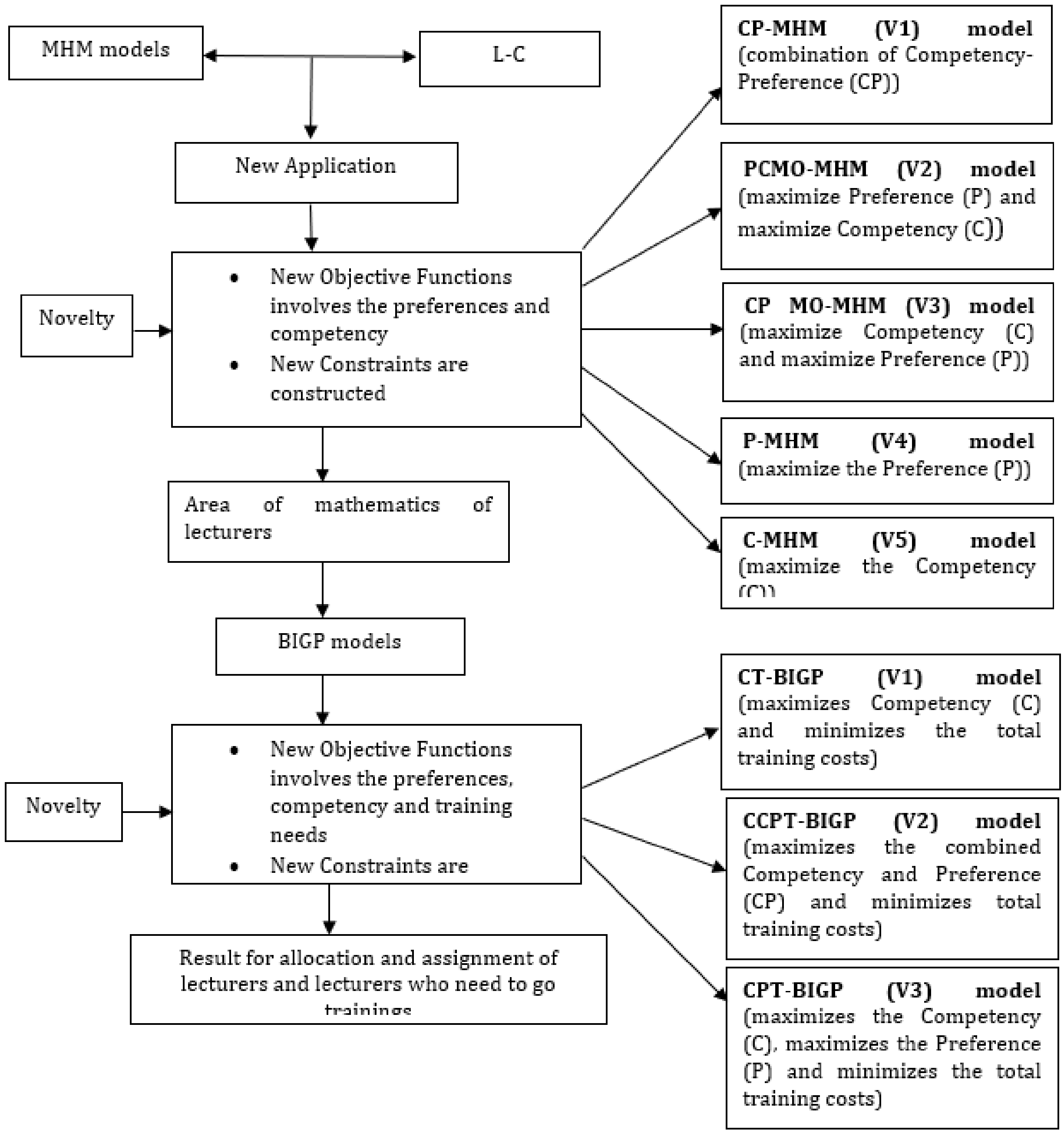

Figure 1. MHM and BIGP Models

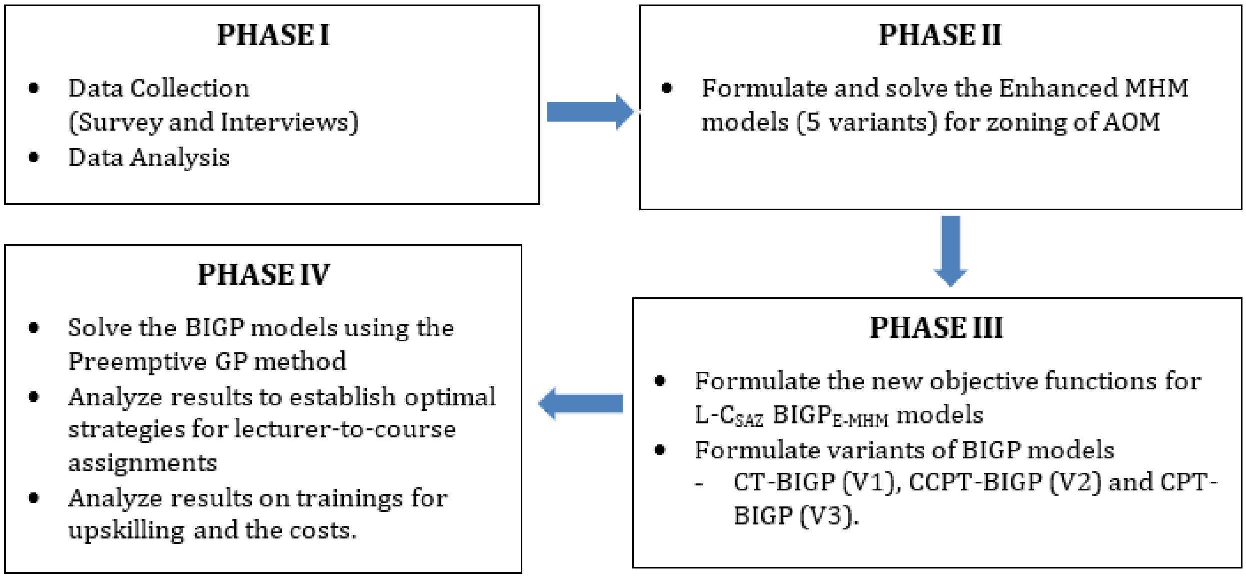

Figure 2. Four Phases of This Study

This project contains four phases to achieve the four objectives as illustrated in **Figure 2**. Phase I focuses on data collection and data analysis for data gathered through survey. Phase II concerns with formulating and solving the modified MHM Model for clustering AOM. Phase III is designated for formulating the new objective functions for the BIGP models and designing the variants of the BIGP models. Lastly, Phase IV involves solving the BIGP models using the Preemptive GP method followed by analyzing all solutions obtained to establish optimal strategies for lecturer-to-course assignments and also trainings required for upskilling and the optimal costs.

Table 1. Summary of All BIGP Model Variants in UiTM Shah Alam

Variant	*Frequent same courses for the three variants*	*Highest number of assigned courses based on lecturers' AOM*	*Lowest total training Cost*	*Lowest Objective Function Value (fval)*	*Total Number of Criteria for Efficient Variant*
V1	/		/		2
V2	/	/			2
V3				/	1

The summary of all BIGP model variants in UiTM Shah Alam shown in **Table 1** has a balanced number of criteria between V1 and V2. V1 and V2 have the highest same frequent assigned courses while V2 has the highest for assigned courses based on lecturers' AOM. Furthermore, V1 has the lowest total training cost among all variants and V3 has the highest objective function value (fval). Based on the total number of criteria for efficient variant, V1 and V2 have the same number of criteria which is 2. To get the best variant, the highest fval between

V1 and V2 is chosen. V2 has the highest fval than V1. Hence, V2 is the best variant among all BIGP models for UiTM Shah Alam.

Table 2. Summary of All BIGP Model Variants in UiTM Seremban

Variant	*Frequent same courses for the three variants*	*Highest number of assigned courses based on lecturers' AOM*	*Lowest total training Cost*	*Lowest Objective Function Value (fval)*	*Total Number of Criteria for Efficient Variant*
V1	/				1
V2		/			1
V3	/		/	/	3

The summary of objective function values of BIGP model variants in UiTM Seremban shown in **Table 2.** The highest objective function value (fval) is V3 followed by V2 and V1. The summary of all BIGP model variants in UiTM Seremban shown in **Table 2** has a balanced number of criteria between V1 and V2. V1 and V3 have the highest same frequent assigned courses while V2 has the highest for assigned courses based on lecturers' AOM. Furthermore, V3 has the lowest total training cost among all variants and has the highest fval. Based on the total number of criteria for efficient variant, V1 and V2 have the same number of criteria which is 1. V3 has the highest total number of criteria for efficient variant which is 3. Hence, V3 is the best variant for BIGP models for UiTM Seremban.

Table 3. Best Variant for Both Campuses

Variant	*Best Variant for UiTM Shah Alam*	*Best Variant for UiTM Seremban*
V1		
V2	/	
V3		/

The most suitable variant of the BIGP models for both campuses is presented in **Table 3.** For UiTM Shah Alam, the optimal variant is V2, while for UiTM Seremban, it is V3. In future applications, faculties with a large number of lecturers and courses can benefit from implementing V2, whereas faculties with a smaller pool of lecturers can adopt V3. These findings provide valuable insights by demonstrating that different campus sizes which are main campus (UiTM Shah Alam) and branch campus (UiTM Seremban) that require tailored approaches, highlighting the effectiveness of model customization for varying institutional needs.

3. Novelty and uniqueness

The novelties of the products are as the following:

a) Lecturers to Courses Structured Assignment by Zoning Binary Integer Goal Programming Models Featuring Enhanced Modified Hungarian Method (L-C_{SAZ} $BIGP_{E\text{-}MHM}$ Models)

b) Unlike traditional methods, which focus solely on maximizing efficiency or competency, this framework considers multiple objectives simultaneously. The three proposed BIGP models (CT-BIGP, CCPT-BIGP and CPT-BIGP) uniquely balance competing goals that are maximizing lecturer competency and preference while minimizing training costs.

c) The E-MHM model solved enables the clustering (zoning) of lecturers based on expertise on teaching Mathematics courses, thus allowing the establishment of the lecturers' Areas of Mathematics (AOM), a strategic tool for academic management that links competency and upskilling to course requirements.

d) The inclusion of lecturer training needs as a core component of the models is particularly innovative as it ensures long-term improvements in teaching quality while optimizing immediate workload distribution. Lecturers' self-identified needs for upskilling in teaching the course embedded in the model allows the estimation of total training costs required for upskilling.

e) Validated and verified based on data of two campuses, the models reflect the solutions which met the characteristics and profiles of lecturers of these campuses, proving their flexibility and scalability.

f) The proposed models offer cost-effective and impactful solutions to improve lecturers' satisfaction and elevate the quality of teaching in higher education institution (HEI).

g) The models can be easily adopted and adapted to suit various settings of assignment problems in various industries, promising solutions at tactical and operational decision-making levels.

4. Benefit to mankind

The proposed models address a critical challenge in higher education which are the efficient and effective allocation and assignment of lecturers to courses. By optimizing assignments based on preferences, competency and training needs, the framework promotes lecturer satisfaction and reduces workload stress, directly improving their well-being. The enhanced allocation process ensures that courses are taught by the most competent and motivated lecturers, leading to higher teaching quality and better learning outcomes for students. Additionally, the inclusion of upskilling strategies equips lecturers with the necessary skills to adapt to evolving academic demands, fostering continuous professional development. Beyond individual institutions, the models, methods and solutions have broader societal benefits. By improving the quality of education, it contributes to producing well-educated graduates capable of addressing global challenges. Its scalability and adaptability make it a powerful tool for advancing the efficiency and quality of education systems worldwide, promoting academic excellence and long-term human capital development.

5. Innovation and Entrepreneurial Impact

The research project promotes innovation by introducing a data-driven, multi-objective optimization models for lecturer-to-course assignments, addressing inefficiencies in academic workload distribution. By integrating advanced mathematical programming models with practical applications, it exemplifies how research can drive impactful, real-world solutions. The project contributes to a culture of entrepreneurship by encouraging data-informed decision-making in higher education management. Its implementation can inspire institutions to adopt innovative approaches for optimizing resources, improving staff satisfaction and reducing costs, fostering a mindset of continuous improvement. Furthermore, the structured and comprehensive models open opportunities for commercialization as a versatile tool for academic institutions worldwide. It can be adapted for other industries with similar assignment challenges such as healthcare or corporate training, creating avenues for collaboration and enterprise. By showcasing the potential of optimization-driven solutions, this project inspires a shift toward innovative problem-solving across sectors, reinforcing the link between research and entrepreneurial growth.

6. Potential commercialization

This innovative framework has significant commercialization potential as a versatile, scalable solution for resource optimization in higher education and beyond. Its primary application lies in academic institutions seeking efficient lecturer-to-course allocation, offering a data-driven tool that enhances decision-making, reduces training costs and improves teaching quality. The framework can be developed into a software solution or integrated into existing university management systems. By providing customizable models tailored to institutional needs, it offers a unique selling proposition for universities aiming to optimize resource utilization and boost operational efficiency. Beyond academia, the framework can be adapted for industries with similar assignment challenges, such as healthcare staffing, project team allocation or corporate training programs. With a focus on maximizing productivity while minimizing costs, it presents a lucrative opportunity for commercialization as a service-based product or software, appealing to a broad market in resource management and organizational efficiency.

7. Acknowledgment

The authors extend their heartfelt gratitude to the Mathematics lecturers and academic administrators at UiTM Shah Alam and Seremban campuses for their invaluable participation, insights and cooperation throughout this project. Their willingness to share their expertise, provide feedback and contribute their time and effort was pivotal to the success of this project. The authors further express their appreciation for the dedication of these individuals to advancing knowledge in the field of mathematics education, which served as a foundation for achieving the objectives of this project.

8. Authors' Biography

Assoc. Professor Dr. Adibah Shuib is an accomplished academic specializing in optimization models in Operations Research and Applied Mathematics. Currently serving at Universiti Teknologi MARA (UiTM), she has made significant contributions to research and teaching, focusing on mathematical programming models, including the multi-objective and goal programming, for resource allocation as well as planning and scheduling problems. With extensive publications in reputable journals, Dr. Adibah's work bridges theoretical advancements and practical applications. Her leadership in supervising postgraduate research and managing impactful projects has strengthened problem-solving approaches in Mathematics. Passionate about fostering analytical skills, Dr. Adibah continues to inspire students and peers, driving academic excellence and innovation specifically in Mathematics and Operations Research.

Dr. Zati Aqmar Zaharudin is a dedicated academic and researcher specializing in applied mathematics and optimization. As a faculty member at Universiti Teknologi MARA (UiTM), she focuses on mathematical modeling, operations research and decision-making techniques to solve complex real-world problems. Her expertise includes resource allocation, goal programming and optimization models, which have been instrumental in advancing research and academic practices. Dr. Zati Aqmar is passionate about guiding students in research and fostering analytical thinking skills. Through her work, she continues to contribute to the development of innovative solutions in applied mathematics, inspiring future generations of researchers and academics.

Nur Syahirah Ibrahim is a PhD candidate in Mathematics at Universiti Teknologi MARA (UiTM), specializing in optimization and mathematical modeling. Her research, titled "Modified Hungarian Method-Based Binary Integer Goal Programming Model for Optimum Allocation of Lecturers to Courses Considering Preferences, Competency, and Training Needs," focuses on developing innovative solutions for lecturer-to-course assignment in higher education. Through her work, she aims to improve teaching quality, lecturer satisfaction, and resource management. Nur Syahirah is dedicated to bridging the gap between theoretical mathematics and practical applications, particularly in educational settings and is passionate about mentoring and inspiring others in academia.