Training needs optimization for lecturers' upskilling using mathematical programming models: A thematic review

Nur Syahirah Ibrahim[1], Adibah Shuib[1#], Zati Aqmar Zaharudin[2]

1 College of Computing, Informatics and Mathematics, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, MALAYSIA.
2 College of Computing, Informatics and Mathematics, Universiti Teknologi MARA (UiTM) Cawangan Negeri Sembilan, Negeri Sembilan, MALAYSIA.
Corresponding author. E-Mail: adibah253@uitm.edu.my; Tel: +60192622348; Fax: +603 55435301.

ABSTRACT "Learning all your life long" is widely applied in the educational field and serves as the impetus for numerous initiatives taken by educators to enhance their professional development strategies in teaching. Course training of lecturers for upskilling is one of the strategies in enhancing the quality of teaching and expertise to deliver the knowledge to the students to ensure the quality of the educational process is in line with the standards that have been set by the Ministry of Higher Education (MOHE), Malaysia. In consequence, training is essential as a performance improvement tool to achieve the expected competency level and preferences satisfaction in assigning lecturers to courses in higher education institutions. However, training needs analysis for lecturers is rarely discussed, especially in terms of lecturers upskilling by attending relevant training courses for teaching respective courses. Besides, based on literature review, limited studies were found on the allocation and assignment of lecturers for training. For this reason, this paper presents a review of various types of training allocation models developed by past research in dealing with various types of problems in enhancing the better allocation of services in specific fields. This paper provides a comprehensive analysis for enhancement of the existing training models and guides for new approach in solving the developed models. This paper proposes that in order to minimize or reduce the training cost for lecturers' upskilling, only identified lecturers that require skills improvement for better competency and those who seek for better satisfaction in terms of courses assigned to them are potential candidates for further training. Training needs analysis and implementation, which can produce skilled educators with enhanced satisfaction level in teaching which contributes towards top quality higher education.

KEYWORDS: Training needs; higher-level education institution; lecturer-course assignment; competency; preference satisfaction
Received 15 November 2024 **Revised** 27 March 2025 **Accepted** 31 March 2025 **Online** 1 April 2025

Review Article

TRANSACTIONS ON SCIENCE AND TECHNOLOGY

INTRODUCTION

Lecturers play a crucial role in shaping well-rounded graduates by not only imparting academic knowledge but also nurturing students' character, discipline, and professional skills (Nurwahidin, 2018; Matos *et al.*, 2022). As higher education faces growing challenges, especially post-pandemic, lecturers must constantly adapt through relevant training to maintain the quality of teaching. Proper training ensures that lecturers meet required competencies and effectively manage assigned courses, leading to a more balanced workload and improved educational outcomes. Upskilling efforts through structured training also simplify the lecturer-to-course assignment process, ensuring both high-quality instruction and lecturer satisfaction. To optimize lecturers' training needs, it is essential to align professional development with evolving teaching demands and workload management. Burnout, a growing issue among lecturers due to excessive workload, has been linked to emotional exhaustion, absenteeism, and reduced teaching effectiveness (Tikkanen *et al.*, 2021).

Proper course allocation not only ensures teaching quality but also supports lecturers' well-being by balancing their workload. Although Mathematical Programming (MP) models, such as Linear Programming (LP), have been widely applied to address various allocation problems, consideration of training needs remains limited. This paper aims to address this gap by developing a Modified Hungarian Method (MHM)-based Binary Integer Goal Programming (BIGP) model. The proposed

model integrates lecturers' competencies, preferences, and training needs to optimize course assignments, enhancing both teaching quality and workload distribution. Further discussion on MP models can be found in the literature review section. The remaining of this paper is organized as follows: Section 2 discusses past studies involving assignment and allocation problem regarding workload and training. Section 3 presents the mathematical solution approaches used in past studies to solve the formulated MP models, along with some potential approaches that may be used in solving future MP models. Section 4 concludes and discusses future work.

LITERATURE REVIEW

According to Zinn *et al.* (2019), there is a critical developmental demand for lecturers to acquire skills on the current technologies through practical-oriented additional training programs. The authors also conclude that pedagogical training, which is the method by which educators teach, both in theory and in practice, of university lecturers is typically the result of a voluntary self-training process based on seminars or training activities, personal readings, and interaction with peers. This means lecturers have different ways of delivering the knowledge which heavily depends on the lecturers' prior experiences as learners which include observations made when they were students and insights from the subject being taught their lecturers. This indicates that through a proper related training for the courses to be taught, a lecturer's skill in teaching this particular course or subject can be improved.

A training needs analysis pinpoints the precise information and abilities that employees require to increase their output, efficiency, and inventiveness at work (Andriotis, 2022). However, Fu *et al.* (2021) emphasized that educators' training must start with greater humanistic attention to professional life quality and mental health rather than only on the professional progress and quality. This implies that training to become a good lecturer or teacher must aim not only to shape professionalism and to meet the expected standard in teaching for the respective level of education, but also to promote mental health and well-being of the lecturer. For example, Dumitru (2015) described teachers' training as comprised of three levels which are the initial training (a pre-work course to become a teacher), the induction training (for teachers who teach in their first years), and the continuous professional training (CPT) that enables teachers to maintain and enhance skillset and knowledge. CPT represents the key for quality services in education since teachers have to implement a set of policies and practices in education, to keep their knowledge and methodologies up to date, and to elevate their professional credentials to remain strong, authentic, and authorized in any temporal context.

University education is regarded as a key consumer of modern technology, as well as regional and international changes in teaching, learning styles, scientific research, and educational quality (Abouelenein, 2016). Based on the study by De Diezmas & Barrera (2021), lack of training, lack of preparation and lack of right approaches are among the main causes that have negative impact on delivering the English Medium Instruction (EMI), which is a university course under this study. In addition, continuous professional development (CPD) for lecturers, as stated by Matos *et al.* (2022), can further develop and enhance teaching quality and reduce the effects of burnout among lecturers, which could safeguard health and wellness of lecturers and most importantly, ensure the quality learning and achievement of students in higher education. Hence, challenges include planning, performing scientific research, and being able to address social issues cause lecturers to become burned out, which will result in poor academic performance, failure, and withdrawal (Abouelenein, 2016). Therefore, to prevent and lessen the present problems or obstacles faced by the lecturers, they need to receive training necessary for their professional development.

Mathematical Programming (MP) is an Operational Research (OR) approach that works with groups of methods for various optimization problems, particularly linear and quadratic optimization problems, for which the Integer Linear Programming (ILP) model is well established as one of the solution approaches (Eraşcu *et al.*, 2021). It is concerned with the optimal allocation of limited resources among competing activities while adhering to a set of constraints given by the nature of the problem under consideration. For example, Bradley *et al.* (1977) mentioned that these constraints could be due to financial, technological, marketing, organizational, or a variety of other factors. Besides, the author stated that MP is a mathematical representation used to program or plan the best feasible allocation of scarce resources. Problems with resource management might cause optimization issues that can be solved by using either exact (simplex method, cutting planes (CP) method, Branch-and-Bound (B&B) method, etc.) or inexact (heuristics and metaheuristic) methods (Eraşcu *et al.*, 2021). This demonstrates that MP is one of the greatest tools for solving decision making problems by determining the best allocation strategy for scarce resources among competing activities. In addition, OR is both an art and a science where art focuses on describing and modelling problems and science focuses on solving the model using mathematical methods (Taha, 2017). Essentially, problem-solving is a component of OR, which can be used in management in decision-making. There are five general steps in solving any MP problem, which are model development, data collection, determining optimal or best solution, conducting sensitivity analysis, testing solution and solution implementation. This indicates that MP model can be applied in training allocation for various areas in industries. Thus, training allocation regarding lecturers to courses can be applied to improve the education system. This underlines the significance of training needs in many industries that would promote a better future in terms of effective and quality outcomes for product processing and labor skills.

University courses require well-trained lecturers to ensure effective teaching and learning. Mathematics courses, for instance, can be categorized into pure mathematics and applied mathematics. Easyuni (2022) describes the characteristics of university programs based on four main factors. First, the quality of education, which emphasizes critical thinking and problem-solving through diverse materials. Second, the internship opportunities that offer real-world work experience for students. Third, research development enables participation in various research activities that enhance knowledge and skills. Lastly, support programs that further enrich students' understanding and abilities in their chosen fields. This emphasizes the importance of training among universities lecturers to develop professional academicians who can fulfill the responsibilities in meeting the expectations of these four characteristics. Therefore, this paper intends to review the related past studies on the staff-to-task assignment and training allocation of various areas that include training allocation for lecturers which have not been discussed in past studies. The main contribution of this paper is to provide a comprehensive analysis for finding a better training allocation model to solve the problem of the training allocation of lecturers. This paper is also expected to highlight the future research direction as the findings of the research could bring new ideas for multiple perspective improvement encompassing all lecturers, not only those in the field of mathematics. The effective lecturer to-course-assignment ensures that each lecturer gets a balanced teaching workload and proper training allocation allows lecturers who need upskilling be determined to enhance the expertise of lecturers to teach the courses.

METHODOLOGY

In this section, the structured review of past studies concerning assignment and allocation regarding workload and training is discussed. The articles regarding these past studies were gathered using the Scopus and Google Scholar search engines, focusing on the "Article Title, Abstract,

Keywords" by using the keywords "Assignment" AND "Allocation" AND "Training" AND "Workload" as shown in Table 1.

Table 1. Summary of the past studies using keywords on Scopus and Google Scholar

No	Author	Search Engine	
		Scopus	Google Scholar
1	Tariri (2013)		✓
2	Amiryan *et al.* (2017)		✓
3	Chen *et al.* (2017)	✓	
4	Chen *et al.* (2018)	✓	
5	Shin *et al.* (2019)	✓	
6	Liu *et al.* (2021)		✓
7	Qin *et al.* (2021)		✓
8	Sujaudeen and Mirnalinee (2022)	✓	
9	Mohan *et al.* (2022)	✓	
10	Zeng *et al.* (2022)		✓
11	Baccara *et al.* (2023)	✓	
Total		**6**	**5**

As a result, only 11 articles were found to be related to assignment and allocation for workload and training that is from the year 2013 until 2023. Most of these past studies present results and analysis rather than as review papers, which where proves that the methods used for training assignment and allocation contribute towards the enhancing the human resource management particularly in the workforce assignment and professional development. All these studies are on optimization models for upskilling of staff by trainings. Thus, it can be said that the number of papers published under this topic is not very encouraging and there is a limited number of papers published. Despite the result showing an increasing trend in research concerning training allocation and assignment, research in the assignment and allocation of lecturers to courses are still lacking especially the ones associated to both preference and competency level simultaneously. Meanwhile, training needs based on competency level in the problem of assignment and allocation of lecturers to courses has not been the focus of any past studies. This motivates the researchers to conduct a study pertaining to assignment and allocation of lecturers to courses based on preferences and competency level as well as determining the needs for upskilling training to enhance lecturers' competency level for certain respective course by one level.

Based on the reviews of past studies, the papers can be divided into two categories which are Assignment and Allocation Regarding Workload and Training (AARWT) and the Approaches of Lecturer to Course Assignment Problem (LTCAP). The analysis made on the AARWT aims to analyse the types of training analysis. Besides that, it is crucial to observe the areas of applications regarding workload and training to investigate whether trainings for lecturers have been implemented. On top of that, the solution method used in these past studies is also analysed. By doing so, it can be seen clearly which method is suitable to solve the problem regarding workload assignment and training that can be recommended for future research. The solution approaches related to assignment and allocation for lecturers training for upskilling that employed MP model were extracted to analyse the approaches used by the authors to solve the problem. The solution approaches can be classified into two types that are exact or approximate methods. This is to provide the insights on which MP model is frequently used to be proposed as solution method in future studies. FIGURE 2 illustrates the steps taken in conducting this thematic review.

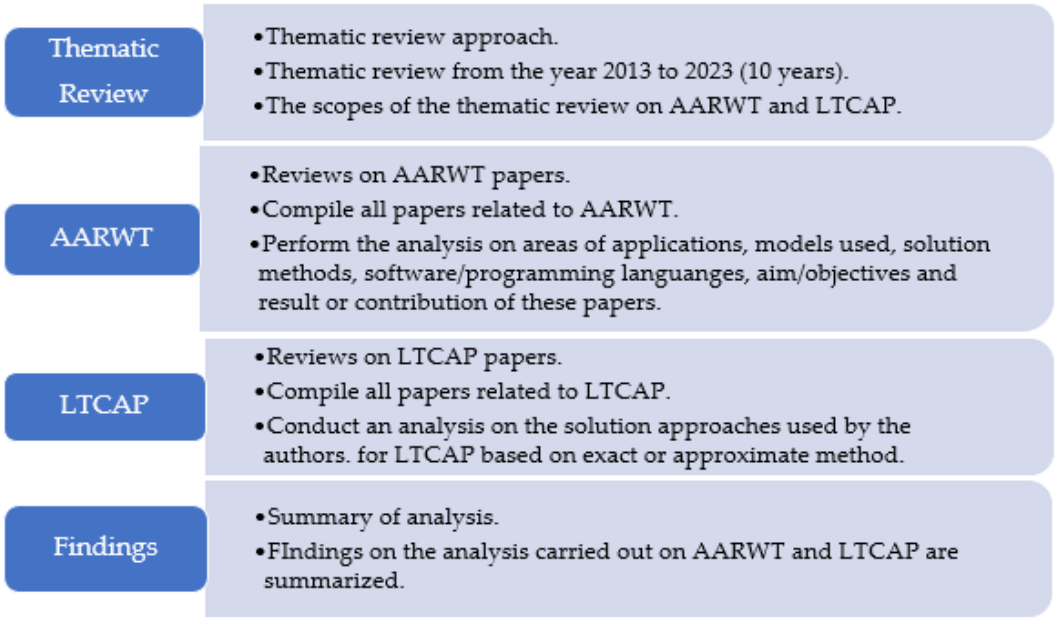

Figure 2. Steps for the Thematic Review.

RESULT AND DISCUSSION

Results presented in this paper comprise of analysis on papers related to Assignment and Allocation Regarding Workload and Training (AARWT) and the Approaches of Lecturer to Course Assignment Problem (LTCAP). Discussion is based on the year 2013 until 2023. Meanwhile, results on LTCAP concern with solution approaches on personnel's training assignment and allocation.

Past Studies of Assignment and Allocation Regarding Workload and Training (AARWT)

From the past studies, there is a scarcity of studies focusing on the assignment and allocation of work and training. Notably, none of these studies address the assignment of lecturers to specific courses based on their training requirements. Most of these studies concentrate on providing diverse training, particularly in multiskilling and ICT-related areas. For instance, Baccara *et al.* (2023) delve into the correlation between task assignment and job training. They explored how businesses can enhance productivity by assigning tasks according to employees' proficiency levels and providing training to enhance their skills. Additionally, they developed a theoretical model to optimize task allocation and training within a company. Meanwhile, Zeng *et al.* (2023) aimed to address issues of workload fairness and overall labour hours in the multi-skilled worker assignment problem within the Seru production system (SPS). The authors take into consideration the skill levels of workers to meet consumer demands with improved production. Additionally, effectively deploying cross-trained workers for enhanced adaptability poses a significant challenge in implementing SPS. SPS exhibits the capability to cater to fluctuating consumer demands for a wide range of product variations in smaller quantities. Furthermore, a study by Liu *et al.* (2021) builds upon prior research regarding the allocation of cross-trained workers. In contrast to most previous research, Liu *et al.* (2021) specifically focus on the hybrid SPS which the proposed method surpasses the original model, which relied on diverse groupings and achieved maximum computational efficiency by minimizing makespan and ensuring balanced workloads for each Seru worker. Considering how challenging it is to raise workers' skill levels through short-term training, the authors emphasize the critical nature of this approach.

Qin *et al.* (2021) devised an optimal workload distribution system for an edge computing network. Their proposed application prediction algorithm effectively reduced device response times and the

average completion time of task sequences, coming close to theoretically ideal outcomes. However, the authors did not extend this allocation method to the training model. Instead, they utilized the training set during the off phase to categorize historical system data, ultimately obtaining the optimal training model before proceeding to the allocation phase for the edge computing network. As a result, the primary emphasis of this study was on the computer network itself rather than on the allocation of training resources. Similarly, Shin *et al.* (2019) conducted a study on the workload-aware auto-parallelization framework (WAP), akin to the approach employed by Qin *et al.* (2021). WAP optimizes the assignment of graphics processing units (GPUs) based on workload computational requirements, thereby enhancing energy efficiency. This study demonstrates the competitive training throughput compared to state-of-the-art frameworks. The authors claim that their suggested methodology significantly enhances training performance in distributed computing clusters, even with small data sizes. Additionally, Sujaudeen and Mirnalinee (2022) introduce a resource management problem aimed at optimizing parameter values to enhance cloud performance. These studies highlight the critical importance of training and testing sets in the allocation of resources, ensuring accurate and efficient results.

Employing a multi-objective approach is crucial for enhancing the efficiency of allocation and assignment processes, as it considers various objectives rather than focusing solely on one. Amiryan *et al.* (2017) conducted a multi-objective analysis regarding cell formation and operator assignment. The authors discovered that while raising production costs reduces lead time, considering reliability and workload balance simultaneously in planning leads to more dependable routes for processing parts. Additionally, the authors take into account cross-training costs, which serve as a benchmark for selecting and assigning operators. In manufacturing systems, one effective strategy for boosting productivity is labour assignment, which takes into consideration the training needs of the workforce. Mohan *et al.* (2022) employ Deep Neural Networks (DNNs) for training tasks to efficiently allocate resources like CPU and memory on multi-tenant clusters. This results in improved utilization of existing resources and better overall objectives for jobs and clusters. These training models play a crucial role for both enterprises and cloud data centres in achieving efficient and equitable workloads.

Similarly, in the aircraft industry, Chen *et al.* (2017) conducted an analysis of the assignment of licensed technicians to maintenance tasks at an aircraft maintenance base. The authors found that providing training and upgrading licenses may not always lead to cost savings or fairness benefits. These findings offer valuable insights for airlines in making informed decisions regarding technician training and workforce planning. Besides that, Chen *et al.* (2018) proposed a bi-layered parallel training architecture that significantly improves the efficiency and resource utilization of large-scale convolutional neural networks. Furthermore, to minimize training costs, Tariri (2013) suggests that organizations aim to assign tasks based on workers' existing skills. Table 2 provides a summary of previous research on task allocation and training from 2013 to 2023, covering a span of 10 years.

Table 2. Assignment and Allocation Regarding Workload and Training (AARWT) for year 2013-2023

No	Author	Area of Application	Training/Workload	Model	Solution Methods	Aim/Objectives	Result or Contribution
1	Baccara *et al.* (2023)	Job Training	Training	Dynamic for queuing	Theoretical proofs	Maximizes performance and minimizes costs	Training technologies improve and minimize the cost
2	Zeng *et al.* (2023)	Multi-Skilled Worker Assignment	Workload	MINLP	(NSGA-II; SPEA2) - A	Minimize total labor hours and workload unfairness	Portrays best solution quality, spacing, density and stretchability
3	Mohan *et al.* (2022)	Scheduling Multi-Tenant Clusters	Workload	IP	(Heuristic algorithm) - A	Maximize throughput; minimize number of jobs	Improved job and cluster-wide objectives
4	Sujaudeen and Mirnalinee (2022)	Task-aware autonomic resource management	Workload	Neural network	(m-PSO algorithm) - A	Maximize usage of resources; minimize loss	Better allocation of resources and schedules tasks appropriately to the resources
5	Liu *et al.* (2021)	Cross Trained Worker Assignment	Workload and Training	MIP	(NSGA-II) - A	Minimize makespan and workload imbalance	Reduces makespan and workload imbalance
6	Qin *et al.* (2021)	Optimal Workload Allocation for Edge Computing Network	Workload	Application prediction	(Long short-term memory (LSTM)) -A	Minimize response delay	Reduces device response delay; achieve optimal allocation
7	Shin *et al.* (2019)	Workload-Aware Automatic Parallelization (WAP)	Workload and Training	DNNs	(Workload-aware Automatic Parallelization) -A	Maximize performance of multi-GPU DNN training; minimize overhead	Improves performance of multi-GPU DNN training than before
8	Chen *et al.* (2018)	Training Architecture	Training	CNNs	(Back Propagation (BP)) - E	Thread-level load balancing; minimizing critical paths waiting time	Improves training performance; maintains the accuracy
9	Chen *et al.* (2017)	Licensed Aircraft Technicians Assignment	Workload	MIP	(Tabu-based Heuristic) - A	Minimize workload inequality and labor costs	Effectively assigns licensed technicians to maintenance tasks
10	Amiryan *et al.* (2017)	Operation Assignment	Workload	MINLP	(NSGA-II) - A	Developing a multi-objective model on cell formation and operator assignment	Increase in operator production costs; reduces lead and processing route's reliability
11	Tariri (2013)	Dependent Costs Assignment	Workload and Training	IP	SAP - E	Maximize workers' preferences and aggregate training; minimize training cost	A multi- objective model optimized workers' preferences while minimizing training costs, outperforming previous methods

The authors tackled the assignment problem considering dependent costs, which involve the expense of training a worker for a task based on their training for other tasks. These studies cover various fields, emphasizing the importance of a multi-objective approach in addressing assignment and allocation challenges. The goal is to align trainings with career goals and skill gaps to empower workers in handling tasks efficiently. These previous studies highlight the critical role of training in improving workforce management and resource allocation across diverse industries.

Solution Approaches from AARWT Studies for Training and Upskilling in Lecturer to Course Assignment (LTCAP)

From this point forward, the discussion revolves around the outcomes derived from an analysis of studies related to the Lecturer to Course Assignment Problem (LTCAP). As illustrated in Table 2, several MP models were utilized to address specific AARWT issues. However, not all of these MP models are applicable for addressing LTCAP concerns regarding the training and upskilling of lecturers. This is because these past studies' areas are very widespread while some of them are too specific on certain scope. Specifically, imbalanced workload assignments were a consequence of gaps in workers' skills, necessitating training for upskilling and multiskilling for equitable job distribution and task assignment, to enhance industry operations' efficiency. Additionally, only a handful of these models can be modified to address the training needs problem for upskilling lecturers in general.

Table 3 sheds light on the solution approaches for selected studies from AARWT for training and upskilling in LTCAP. Based on Table 3, there is still a deficiency in research dedicated to LTCAP, despite its critical role in advancing higher education. Moreover, addressing the training needs of lecturers is essential for professional development, especially in the context of upskilling, which contributes significantly to the enhancement of knowledge, skills, and teaching motivation. Having competent lecturers who specialize in teaching specific groups of courses by field or expertise makes it easier for lecturer-to-course assignment process. Furthermore, assigning lecturers to courses that align with their preferences and expertise leads to high-quality teaching and learning experiences and benefits the well-being of the lecturer. Besides that, further enhancement of lecturers' competencies through upskilling allows for better allocation and assignment of lecturers, resulting in a more balanced workload.

To gain a deeper insight into LTCAP, a comprehensive analysis is conducted on the MP models, considering the interdependence of the entire models and their solution approaches. Table 3 provides an overview of the MP models used and the solution approaches for selected studies from AARWT for training and upskilling in LTCAP involved, which may be either approximate or exact method. In contrast to the exact method, it is noted that the approximate method, which typically yields near-optimal solutions is favoured when dealing with large-scale problems. Nine previous studies used the approximate method to solve their proposed models, while three studies applied the exact method. Another reason why the approximate method is attributed by most authors is that the assignment and allocation problems involve complex, combinatorial, and strongly constrained problems with hard and soft constraints. Therefore, the problems become more complex due to the large number of decision variables and large constraints.

Obtaining the optimal solutions requires a significant amount of computational time. IP (BIP, MIP) models are commonly used to address assignment and allocation problems in specific areas of application, including training lecturers for upskilling, as IP models deal with real and integer value decision variables. MP models solved with exact methods such as Simplex, Branch-and-Bound (B&B) and Cutting Plan ensure an optimal solution. However, exact methods become impractical and computationally challenging for large-scale problems. Metaheuristic algorithms (NSGAA II, SPEA2,

Particle Swarm Optimization (PSO) and Dragonfly Algorithm (DA)) are widely utilized as effective approaches for solving large-dimensional optimization problems that are too complex and unattainable using exact methods.

Table 3. Solution approaches for selected studies from AARWT for Training and Upskilling in LTCAP

No.	Author	Area of Application	Method/Algorithm/Software	Mathematical Programming (MP) Model		
				IP	MIP	MINLP
1	Zeng *et al.* (2023)	Multi-Skilled Worker Assignment	Approximate /NSGA-II and SPEA2/CPLEX			✓
2	Mohan *et al.* (2022)	Scheduling on Multi-Tenant Clusters	Approximate/Heuristic/Python	✓		
3	Liu *et al.* (2021)	Cross Trained Worker Assignment	Approximate /NSGA-II/Lingo		✓	
4	Chen *et al.* (2017)	Licensed Aircraft Technicians Assignment	Approximate /Tabu-based Heuristic/CPLEX		✓	
5	Amiryan *et al.* (2017)	Operator Assignment	Approximate/NSGA-II/CPLEX			✓
6	Tariri (2013)	Dependent Costs Assignment	Exact/ SAP/MATLAB	✓		

Note: IP- Integer Linear Programming; BIP- Binary Integer Linear Programming; MIP- Mixed integer programming; MINLP- Mixed Integer Non-Linear Programming; NSGA-II- Nondominated Sorting Genetic Algorithm II; SPEA2- Strength Pareto Evolutionary Algorithm 2; SAP- Shortest Augmenting Path

Tariri (2013) and Mohan *et al.* (2022) utilized IP model approaches to address upskilling training challenges. Tariri (2013) developed the IP model while considering interdependencies among assignment costs, systematically addressing the problem. Meanwhile, Mohan *et al.* (2022) tackled the intricate scheduling challenge associated with DNN operations on multi-tenant clusters using the IP model, providing an optimal schedule to enhance overall system performance. The IP model considers various factors influencing the efficacy of DNN workloads on multi-tenant clusters, including data locality, resource contention, and workload dependencies.

Liu *et al.* (2021) and Chen *et al.* (2017) applied MIP models to address assignment problems. Chen *et al.* (2017) specifically utilized the MIP model to allocate skilled professionals to maintenance tasks, incorporating a Tabu search algorithm to optimize the assignment of technicians to licensed aircraft. In contrast, Liu *et al.* (2021) employed the NSGA-II approach to solve the MIP model to enhance production efficiency, optimize resource utilization, and improve worker productivity, particularly for cross-trained individuals. Amiryan *et al.* (2017) and Zeng *et al.* (2023) applied the NSGA-II approach to solve MINLP models. Amiryan *et al.* (2017) utilized NSGA-II to address the multi-objective nature of the cell formation and operator assignment problem. Similarly, Zeng *et al.* (2023) applied NSGA-II to tackle the proposed MINLP model with competing objectives, focusing on the efficient allocation of multi-skilled workers. Various models and frameworks have been proposed to optimize assignments, focusing on factors such as fairness, efficiency, and satisfaction. Our study proposes the combination of the Modified Hungarian Method (MHM) and Binary Integer Goal Programming (BIGP) model to determine optimal solution to assignment and allocation to courses considering lecturers' preferences, competency, and training needs. The proposed models and methods also aim in reducing the training cost by assigning specific lecturers to training courses based on current and expected competency levels.

CONCLUSION

Solution to lecturer-to-course assignment and allocation problem is critical towards ensuring lecturers' preference satisfaction as well as fair and balanced workload assignment and burnout prevention among lecturers and quality education for students in higher learning institutions. Methods and approaches for lecturer-to-course assignment and allocation problems have been the prime motivations to conduct our study. This paper presents a review of some past studies concerning the staff-to-task assignment and training allocation. Analysis on papers related to AARWT indicates the importance of training in enhancing workforce assignment and allocation in diverse areas of industries. Comprehensive analysis in this paper provides insights on lecturers' assignments to courses and training allocation models for lecturers. Appropriate trainings allocations enable upskilling and expertise enhancement of the lecturers which could lead to higher productivity and quality in education. This paper also provides an overview of past studies related to AARWT and LTCAP by focusing on MP models of lecturers' assignment and allocation to courses and lecturers' trainings for upskilling. The gap analysis contributes towards development of new MP model which addresses the problem by considering lecturers' various fields of expertise, preferences, and competency levels which require trainings consideration for upskilling. The MP model has been considered due to its systematic way of modelling the problem and producing optimal solutions which can minimize the training costs by assigning lecturers to training programs based on their current and expected competency levels of the identified courses to be taught or preferred. Our study combines the MHM and BIGP models which involve multiple objective functions to be solved using the preemptive GP method to determine optimal solution for lecturers-to-courses assignment and allocation problem and to establish strategies for lecturers' training for upskilling. Analysis of past studies also revealed suitable methods that can be employed in solving the proposed MP model.

ACKNOWLEDGEMENTS

This study has been funded by UiTM grant no 600-RMC/GIP 5/3 (022/2023).

REFERENCES

1. Abouelenein, Y. A. M. 2016. Training Needs for Faculty Members: Towards Achieving Quality of University Education in the Light of Technological Innovations. *Educational Research and Reviews*, 11(13), 1180–1193.
2. Amiryan, K., Mohammadi, R. A. & Mahmoudabadi, A. 2017. Developing a Multi-Objective Model on Cell Formation and Operator Assignment Based on Reliability and Workload Planning. *International Technology and Science Press*, 1, 28–49.
3. Andriotis, N. 2021. *Why You Need to Run a Training Needs Assessment (And How To Do It)* (https://elearningindustry.com/why-need-to-run-training-needs-assessment). (Last accessed on 26 March 2025).
4. Baccara, M., Lee, S. & Yariv, L. 2023. Task Allocation and On-the-Job Training. *Journal of Economic Theory*, 207, 105587.
5. Bradley, H., Hax, A. C. & Magnanti, T. L. 1977. *Applied Mathematical Programming*. Addison-Wesley Publishing Company.
6. Chen, G., He, W., Leung, L. C., Lan, T. & Han, Y. 2017. Assigning Licenced Technicians to Maintenance Tasks at Aircraft Maintenance Base: A Bi-Objective Approach and A Chinese Airline Application. *International Journal of Production Research*, 55(19), 5550–5563.
7. Chen, J., Li, K., Bilal, K., Zhou, X., Li, K. & Yu, P. S. 2018. A Bi-layered Parallel Training Architecture for Large-Scale Convolutional Neural Networks. *IEEE Transactions on Parallel and Distributed Systems*, 30(5), 965–976.

8. De Diezmas, E. N. M. & Barrera, A. F. 2021. Main Challenges of EMI at the UCLM: Teachers' Perceptions on Language Proficiency, Training and Incentives. *Alicante Journal of English Studies*, 34, 39–61.
9. Dumitru, G. 2015. The Teacher's Perceptions Toward the Continuous Training Programs and Identifying the Achieved Competences. Procedia - Social and Behavioral Sciences, 180, 802–807.
10. Easyuni. 2025. *Study Mathematics & Statistics in Malaysia. Everything you need to know about studying Mathematics & Statistics in Malaysia*. https://www.easyuni.my/en/malaysia-mathematics/ (Last accessed on 26 March 2025).
11. Eraşcu, M., Micota, F. & Zaharie, D. 2021. Scalable Optimal Deployment in the Cloud of Component-Based Applications using Optimization Modulo Theory, Mathematical *Programming and Symmetry Breaking. Journal of Logical and Algebraic Methods in Programming*, 121, 100664.
12. Fu, Q., Yao, J., Tan, Q. & Gui, R. 2021. Teacher Training Needs and their Influencing Factors: A Case Study of 13 Chinese Border School Teachers. *International Journal of Learning, Teaching and Educational Research*, 20(10), 331–349.
13. Liu, F., Niu, B., Xing, M., Wu, L. & Feng, Y. 2021. Optimal Cross-Trained Worker Assignment for a Hybrid Seru Production System to Minimize Makespan and Workload Imbalance. *Computers & Industrial Engineering*, 160, 107552.
14. Matos, M. D. M., Sharp, J. G. & Iaochite, R. T. 2022. Self-efficacy Beliefs as a Predictor of Quality of Life and Burnout Among University Lecturers. *Frontiers in Education*, 7, 887435.
15. Mohan, J., Phanishayee, A., Kulkarni, J. & Chidambaram, V. 2022. Looking Beyond GPUs for DNN Scheduling on Multi-Tenant Clusters. *Proceedings of the 16th USENIX Symposium on Operating Systems Design and Implementation (OSDI 2022)*. pp 579–596.
16. Nurwahidin, M. 2018. Well-Being on Lecturer: Reviewed from Gratitude and Religiosity. *International Journal of Engineering & Technology*, 7(2.29), 651–654.
17. Qin, Z., Cheng, Z., Lin, C., Lu, Z. & Wang, L. 2021. Optimal Workload Allocation for Edge Computing Network Using Application Prediction. *Wireless Communications and Mobile Computing*, 2021, 1–13.
18. Shin, S., Jo, Y., Choi, J., Venkataramani, S., Srinivasan, V. & Sung, W. 2019. Workload-aware Automatic Parallelization for Multi-GPU DNN Training. *ICASSP 2019 - IEEE International Conference on Acoustics, Speech and Signal Processing*. pp 1453–1457.
19. Sujaudeen, N. & Mirnalinee, T. T. 2022. TARNN: Task-Aware Autonomic Resource Management Using Neural Networks in Cloud Environment. *Concurrency and Computation: Practice and Experience*, 34(8), e5463.
20. Taha, H. A. 2017. *Operational Research: An Introduction* (10th ed.). Pearson.
21. Tariri, G. 2013. *The Assignment Problem with Dependent Costs*. PhD Thesis, University of Louisville, Louisville, Kentucky, USA.
22. Tikkanen, L., Pyhältö, K., Soini, T. & Pietarinen, J. 2021. Crossover of Burnout in the Classroom – Is Teacher Exhaustion Transmitted to Students? *International Journal of School & Educational Psychology*, 9(4), 326–339.
23. Zeng, S., Wu, Y. & Yu, Y. 2023. Multi-Skilled Worker Assignment in Seru Production System for the Trade-Off Between Production Efficiency and Workload Fairness. *Kybernetes*, 52(9), 3495-3518.
24. Zinn, B., Raisch, K. & Reimann, J. 2019. Analysing Training Needs of TVET Teachers in South Africa: An Empirical Study. *International Journal for Research in Vocational Education and Training*, 6(2), 174–197.