



**JOURNAL OF INFORMATION
SYSTEM AND TECHNOLOGY
MANAGEMENT
(JISTM)**

www.gaexcellence.com/jistm



UNIVERSITY LECTURER TIMETABLING: A COMPREHENSIVE LITERATURE REVIEW OF CHALLENGES, SOLUTIONS, AND FUTURE DIRECTIONS

Noor Hafizah Zainal Aznam^{1*}, Kartini Kasim², Amirah Hazwani Abdul Rahim³, Siti Fairus Mokhtar⁴, Shahida Farhan Zakaria⁵

¹Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Kedah Branch, Malaysia.

 noorhafizah@uitm.edu.my

 <https://orcid.org/0000-0001-6369-8782>

²Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Kedah Branch, Malaysia.

 kartini2929@uitm.edu.my

 <https://orcid.org/0009-0001-1712-1736>

³Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Kedah Branch, Malaysia.

 amirah017@uitm.edu.my

 <https://orcid.org/0009-0009-6118-2657>

⁴Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Kedah Branch, Malaysia.

 fairus706@uitm.edu.my

 <https://orcid.org/0009-0003-5415-6705>

⁵Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Kedah Branch, Malaysia.

 shahidafarhan@uitm.edu.my

 <https://orcid.org/0009-0002-9366-414X>

*Corresponding Author

Article Info:

Article history:

Received date: 30.07.2026

Revised date: 24.08.2026

Accepted date: 23.09.2026

Published date: 30.09.2026

To cite this document:

Aznam, N. H. Z., Kasim, K., Rahim, A. H. A., Mokhtar, S. F., & Zakaria, S. F. (2026). University Lecturer Timetabling: A Comprehensive Literature Review Of Challenges, Solutions, And Future Directions. *Journal of*

Abstract:

Timetable preparation for university lecturers is a complex activity that has implications for the delivery of academic programs, use of resources, lecturers' working patterns, and stakeholder satisfaction. The aim of this review is to identify and synthesize the main challenges, solution approaches, research gaps, and future directions for scheduling university lecturers. A structured literature review was performed using the Scopus-indexed publications for the period 2009-2025. Nineteen relevant studies were identified by predefined screening and eligibility criteria and analysed by descriptive classification and thematic synthesis. The results show that the lecturer timetabling depends on the computational complexity, the necessity to satisfy hard and soft constraints, the availability of rooms and teaching periods, interdepartmental coordination, lecturer availability, and scheduling policies that are specific to each institution. The existing methodologies include mathematical programming, graph-colouring techniques, heuristics, genetic algorithms, hybrid metaheuristics, fuzzy constraint models, automated systems, and adjustable timetabling frameworks. These advances in timetable feasibility and computational performance

*Information System and
Technology Management, 11
(44), 837-858.*

are however still limited in terms of scalability, institutional adaptability, practical implementation, preference handling, and the limited evaluation of workload balance and timetable fairness. Recent research indicates a gradual shift from feasibility-centred optimisation to more flexible, preference-aware, and stakeholder-responsive systems. Integrating computational, institutional, and lecturer-centred perspectives, this review demonstrates that future timetabling systems should balance operational efficiency with adaptability, transparency, and fair scheduling outcomes.

DOI: 10.35631/JISTM.1144050

Keyword:

Course Scheduling; Lecturer Preferences; Literature Review; Optimisation; Timetable Fairness; University Lecturer Timetabling



© The authors (2026). This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY NC) (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact jistm@gaexcellence.com.

Introduction

Universities are increasingly required to deliver diverse academic programmes while making efficient use of limited teaching spaces, qualified lecturers, and available instructional periods. Within this environment, academic timetabling is an important planning activity because it determines when and where teaching takes place, who delivers each course, and how institutional resources are distributed. The quality of a timetable can influence programme delivery, classroom utilization, student access to courses, lecturers' working patterns, and the institution's ability to respond to changes in enrolment and curriculum requirements. Timetabling decisions may also have longer-term implications for staffing, teaching-space planning, programme structure, and institutional policy, making the problem both operational and strategic in nature (Lindahl et al., 2018). However, the increasing number of courses, lecturers, student groups, rooms, and institutional requirements have made the creation of timetables more and more difficult. Manual methods are time-consuming, error-prone, inconsistent and require frequent revisions, especially when a change in one assignment affects many other parts of the schedule (Álvarez et al., 2014; Hosny, 2019; Zunino et al., 2024). These conditions indicate the necessity of developing systematic methods for producing feasible and practical university lecturer timetables.

Lecturer timetabling is the process of assigning lecturers and their teaching activities to suitable time slots and teaching spaces for a university, subject to different academic, operational and institutional constraints. It is often regarded as a subproblem of the wider University Course Timetabling Problem that aims to coordinate courses, lecturers, student groups, rooms, and time periods within an integrated structure for scheduling (Abdipoor et al., 2023b; Aizam et al., 2019). The requirements that control this process are commonly categorized as hard or soft constraints. Hard constraints are mandatory conditions that must be strictly satisfied such as

ensuring lecturers, rooms, and student groups are not assigned to more than one activity at the same time, verifying that room capacities are sufficient, and scheduling activities only during periods when the assigned lecturers are available. Soft constraints represent desirable conditions that improve timetable quality, including accommodating lecturers' preferred periods, reducing gaps between classes, avoiding consecutive or undesirable teaching slots, and distributing teaching assignments appropriately (Alghamdi et al., 2020; Yavuz et al., 2023). Lecturer timetabling is a Nondeterministic Polynomial (NP)-hard combinatorial optimisation problem, and the solution space increases exponentially when the institutional problem increases (Abdipoor et al., 2023b; Davoudzadeh et al., 2009). These requirements often compete for limited rooms and time slots so that timetable can be technically feasible, but operation-wise inefficient or unacceptable to the lecturers. This underscores the need to highlight both constraint satisfaction and timetable quality.

A substantial body of research has been done on university timetabling using mathematical programming, graph-colouring methods, heuristics, genetic algorithms, hybrid metaheuristics, fuzzy techniques, and automated scheduling systems. The techniques have been proven to be more efficient in exploring the large search space and generating feasible solutions (Adewumi et al., 2009; Chong-Keat et al., 2015; Hidzir & Nordin, 2018; Yusoff & Roslan, 2019). Nevertheless, several gaps remain. First, most of the existing literatures have focused on general course timetabling with less attention paid to the specific aspects related to lecturers such as individual availability, workload distribution, timetable gaps, interdepartmental teaching, preferred periods, and undesirable assignments. Second, most of the presented methods are designed for specific institutional settings or benchmark datasets and are not easily adaptable to different academic policies, programme structures, room types, and lecturer-assignment practices (Abdipoor et al., 2023b; Ahmad et al., 2012). Third, algorithmic performance is often evaluated based on computational time, constraint satisfaction, or objective-function values, while their practical applicability, stakeholder acceptance, and implementation within university scheduling workflows are rarely discussed. Although international competitions have promoted the standardization and benchmarking of methods, achieving high performance on benchmarks does not automatically guaranty adaptability to real institutional environments (Abdipoor et al., 2023a; Müller et al., 2018). While recent preference-based models, fuzzy constraints, and rule languages have begun to address these shortcomings, the evidence is scattered across different methodological traditions (Babaei et al., 2016; Behuet et al., 2024; Lam et al., 2025; Zunino et al., 2024). Therefore, a comprehensive review is needed to connect computational advances with the practical and human aspects of lecturer timetabling.

Thus, the objective of this review is to comprehensively identify, classify, and synthesize the challenges, solution approaches, and future directions documented in the literature on university lecturer timetabling. The four objectives of the review are: It first examines the dominant computational, operational, institutional, and lecturer-related problems bearing on timetable construction. Secondly, it classifies the methods developed to overcome such issues, which are mathematical programming, constraint-based modelling, graph-colouring techniques, heuristics, metaheuristics, hybrid algorithms, fuzzy approaches, automation systems, and configurable frameworks. Thirdly, these approaches are critically reviewed in terms of solution quality, computational efficiency, scalability, adaptability to institutions, handling of lecturer-preference and applicability to the actual case. Finally, it discusses outstanding research gaps and proposes future directions for developing more flexible, transparent, stakeholder-responsive and human-centred timetabling systems. The review is not

limited to a comparison of algorithms and brings the lecturer-related issues in the larger university timetabling sector to the fore. It explores how timetable solutions might better match institutional efficiency with the professional demands of lecturers.

The rest of this paper is organized as follows. The Methodology section outlines the review design, research topics, information source, search strategy, study-selection criteria, data extraction, quality rating, and synthesis procedures. In the Results section, the included studies are profiled and presented using four analytical themes: computational complexity and resource constraints; mathematical, heuristic, and hybrid solution approaches; lecturer preferences, automation, and user-oriented systems; scalability, institutional adaptability, benchmarking, and future development. In the Discussion, findings are interpreted according to the review questions and the theoretical, practical, and policy implications, major tensions, research gaps, future directions, and review limitations are discussed. Finally, the Conclusion summarizes the review's contribution and its significance for the development of efficient, adaptable, and lecturer-centred timetabling systems.

Methodology

A structured comprehensive literature review design was used to identify, evaluate, and synthesize studies on university lecturer timetabling. The systematic approach was adopted as it provides an organised and replicable procedure for discovering relevant publications using predefined selection criteria, assessing study quality and integrating evidence across studies (Kitchenham & Charters, 2007; Tranfield et al., 2003). The systematic review process was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021), particularly the standards for identification, screening, eligibility of studies and transparent reporting. While PRISMA was originally developed for health-related evidence synthesis, its reporting principles are acceptable for reviews in computing, operations research, and educational management when adapted to the nature of the relevant literature. Thus, this methodology was found to be appropriate to study the computational, operational, and lecturer-related aspects of university timetabling.

The main purpose of the review was to identify, classify, and synthesize the challenges, solutions, and future directions documented in university lecturer timetabling research. The research questions (RQs) were developed before the search, since clearly defined questions guide keyword selection, database choice, screening criteria, data-extraction categories and synthesis procedures (Kitchenham & Charters, 2007). To ground problems in well recognised concerns, prior reviews and foundational studies were explored, including computational complexity, institutional constraints, lecturer preferences, scalability and practical implementation. The review addressed the following three RQs:

- RQ1: What are the challenges of university lecturer timetabling in the literature?
- RQ2: What are the proposed approaches and solution methods to overcome these challenges?
- RQ3: What are the limitations, gaps, and future research directions that can be identified from the current evidence?

To cover the core fields contributing to university timetabling research, Scopus was chosen as the primary database due to its extensive indexing of peer-reviewed literature in computer science, operations research, engineering, education, and management. Many discoveries in

optimisation and educational timetabling are published through computing and operations research conferences and it was vital for coverage of journal articles, conference papers, reviews and book chapters. The database also included systematic record management using structured bibliographic data such as authors, titles, publication years, abstracts, keywords, source titles, and digital object identifiers. Only publications that satisfied the predefined eligibility criteria were retained in the final evidence set.

The Scopus search was conducted on 23 August 2026 and covered publications published between 2009 and 2025. An exploratory natural-language query “What are the challenges, solutions, and future directions in university lecturer timetabling?” was used to refine the concepts. The following Boolean search string was developed: (“university” OR “higher education” OR “college”) AND (“lecturer” OR “instructor” OR “faculty” OR “teacher”) AND (“timetabling” OR “scheduling” OR “planning” OR “allocation”) AND (“challenges” OR “issues” OR “problems” OR “barriers”) AND (“solutions” OR “strategies” OR “approaches” OR “methods”). In each set of concepts, the synonyms were connected with the operator OR and the five groups were combined with AND. The search phrases were applied to titles, abstracts, and keywords of publications. The search was limited to scholarly publications in English related to higher education with no geographical limitation. All retrieved records were exported from Scopus as a CSV file containing bibliographic data, abstracts, and author keywords for later screening.

Studies were eligible for inclusion if they: (a) examined timetabling or scheduling in a university, college, or similar higher-education setting; (b) addressed lecturer assignment, availability, preferences, teaching workload, course scheduling, room allocation, or other constraints relevant to lecturer timetabling; (c) proposed, evaluated, reviewed, or compared a timetabling method, model, algorithm, system, framework, or practical application; (d) provided sufficient methodological or conceptual information to support data extraction; and (e) were published in English between 2009 and 2025. Eligible publication types comprised peer-reviewed journal articles, conference papers, review articles, and academic book chapters. Studies were excluded if they: (a) addressed scheduling outside the context of higher education; (b) focused exclusively on unrelated applications such as agriculture, transportation, healthcare, or industrial production; (c) studied examination timetabling without a significant connection to lecturer or course scheduling; (d) were editorials, presentation slides, abstracts with insufficient methodological detail, or non-scholarly material; or (e) were duplicates of another retrieved record.

The study selection process was based on the identification, screening and eligibility phases suggested by PRISMA 2020 (Page et al., 2021). The search in Scopus yielded 20 records. Duplicate checking found no repeated records. The titles and abstracts were screened against the review questions and predefined eligibility criteria. One record was excluded as it examined machine learning methods for predicting maize yields rather than timetabling in higher education. The full texts of the remaining 19 records were then reviewed for their institutional background, study objectives, methodology, findings and consideration of lecturer-related factors. All 19 records satisfied the eligibility criteria and were included in the final review. A review log was maintained to provide an auditable link between the original search results and the final evidence base and to record screening choices and reasons for exclusion.

The final sample consisted of a wide variety of approaches, including mathematical formulations, graph-colouring methods, heuristic and metaheuristic algorithms, fuzzy and

preference-based techniques, automated timetabling systems, adaptive modelling frameworks, and international timetabling benchmarks. Figure 1 shows the process from the 20 records identified in the initial search to the 19 records considered in this review. This process allows a clear visual representation based on the PRISMA 2020 guidance (Haddaway et al., 2022; Page et al., 2021).

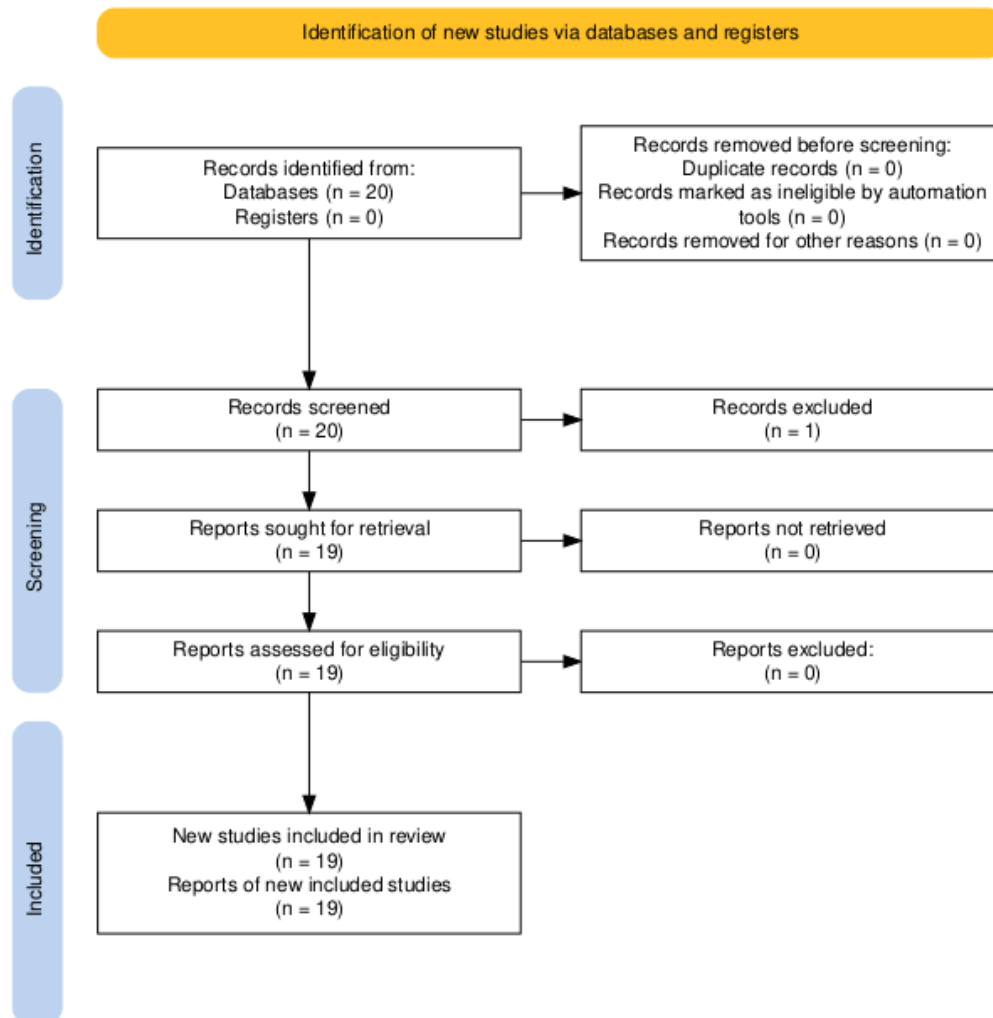


Figure 1: PRISMA Flow Diagram of the Study Selection Process

A standardized extraction framework was used to collect comparable information from each included study. Bibliographic data supplied were the authors, publication year, title, publication type, source title, and geographical or institutional context where reported. Methodological data covered the timetabling problem addressed, research design, proposed algorithm or solution approach, experimental or institutional dataset, problem size, software or computational environment, and comparison methods. Problem-specific information included the decision variables, hard and soft constraints, lecturer-related considerations, resource limitations, and objectives used to evaluate timetable quality. Outcome data included computational time, feasibility, constraint violations, solution quality, room utilization, preference satisfaction, scalability, and other performance measures reported by the authors. Information concerning methodological limitations, implementation barriers, research gaps,

and recommendations for future work was also extracted because these elements were directly relevant to the review questions.

The methodological quality of each included publication was assessed using an appraisal checklist adapted from systematic-review guidance for computing and evidence-based research (Kitchenham & Charters, 2007; Tranfield et al., 2003). Five dimensions were examined: clarity of the research objective, adequacy of the timetabling-problem description, transparency of the proposed method, appropriateness of the evaluation or validation procedure, and completeness of the reported results and limitations. Each dimension was rated as yes, partly, or no, corresponding to scores of 2, 1, and 0, respectively. The scores were summed to produce a maximum quality score of 10 for each study. Quality appraisal was not used automatically to remove studies that had already satisfied the inclusion criteria. Instead, it was used to determine the strength of the evidence and to ensure that conclusions were not based disproportionately on studies with limited methodological reporting. Studies with lower scores were retained when they contributed relevant conceptual or historical information, but their findings were interpreted cautiously.

The included studies showed variation in problem formulations, datasets, constraints, methods, and performance measures. A statistical meta-analysis was not viable and its exclusion in favour of a qualitative synthesis was methodologically justified. The findings were thus synthesized using descriptive classification and thematic analysis. Descriptive classification and thematic analysis were employed to synthesize the findings. First, descriptive analysis was conducted to provide an overview of the publishing years, methodological categories, research contexts, constraint types, and evaluation measures. Second, extracted remarks were categorised into three review domains of challenges, approaches to solutions, and future directions. Similar codes were analysed and categorised into overarching themes, based on Braun and Clarke (2006). The initial topic included codes about NP-hardness, conflicts, and resource scarcity. The second theme was mathematical, heuristic, metaheuristic, and hybrid methods. The third theme was lecturer preferences, automation, and user-oriented design and the fourth theme was scalability, adaptability, and benchmarking. The themes were then examined across research to identify convergence, tensions, and omissions. Specific emphasis was made to whether workload balance, fairness, lecturer preferences, and institutional adaptation were either formulated, measured, or merely recommended. This process explains how the review moved from extracted study-level data to the four cross-study themes reported in the Results section.

Prior to synthesizing the findings, the review questions, search string, eligibility criteria, extraction categories, and quality-assessment procedure were predefined to ensure transparency, consistency and reliability. Every retrieved record was assessed against identical criteria and reasons for exclusion and screening decisions were recorded in a review log. A standardised extraction form and coding instructions were used to ensure that comparable information was collected from all included studies. Uncertain cases were re-examined against the full eligibility criteria, and the extracted information was validated against the original articles prior to synthesis to reduce categorisation errors. The search strategy, search date, database, selection totals, evaluation criteria, and analytical categories are explicitly documented to enable subsequent researchers to analyse and recreate the review process. These measures are aligned with the concepts of systematic, transparent, and reproducible evidence synthesis advised by Page et al. (2021) and Tranfield et al. (2003).

Results

A comprehensive search and screening resulted in a final sample of 19 relevant studies published between 2009 and 2025. The sample included journal articles, conference papers, review studies, and scholarly book chapters addressing university course timetabling, lecturer scheduling and assignment, resource allocation, and automated timetable production. The earliest included publications examined linear and heuristic solutions for university timetabling (Adewumi et al., 2009; Davoudzadeh et al., 2009). The most recent study applied a genetic algorithm with fuzzy constraints to lecturer assignment (Lam et al., 2025). Other areas of research included genetic and hybrid algorithms, graph-colouring methods, mathematical programming, clustering, configurable rule languages, user interfaces, and international benchmark problems. Thus, the final sample represented both the methodological development of university timetabling and the gradual expansion of the field toward lecturer preferences, institutional adaptability, and practical implementation.

The time distribution shows that the research activity was increasingly focused after 2018. Six studies were published between 2009 and 2016, six studies between 2018 and 2020, and seven studies between 2023 and 2025. The literature was varied with contributions from operations research, computer science, artificial intelligence, educational technology, and institutional planning. Most of the primary studies addressed timetabling as an optimisation problem and tested a proposed solution with institution-specific data or benchmark instances. Examples included a Malaysian faculty timetable (Chong-Keat et al., 2015), lecturer-timetabling datasets used to compare genetic and hybrid genetic algorithms (Yusoff & Roslan, 2019), and a classroom-minimisation case involving a Turkish university department (Yavuz et al., 2023). Other publications evaluated optimisation and metaheuristic techniques (Abdipoor et al., 2023b; Alghamdi et al., 2020; Hosny, 2019) or examined benchmark development through international timetabling competitions (Abdipoor et al., 2023a; Müller et al., 2018). In general, the lecturers were modelled by course assignments, availability restrictions, time-slot preferences, faculty-load requirements, or interdepartmental teaching responsibilities.

The 19 studies resulted in three major findings. The primary technological challenge in the field continues to be feasibility. Most models consider conflict avoidance and the satisfaction of hard and soft constraints under scarce rooms, lecturers, and teaching periods. Second, genetic algorithms, hybrid metaheuristics, and other flexible search methods are prominent due to their ability to handle large solution spaces. However, their reported performance is difficult to compare across institution-specific datasets, and penalty structures. Third, recent studies increasingly include lecturer preferences, automation, adjustable rules, and user interfaces, but workload balance, timetable fairness, lecturer acceptability, and cross-institutional validation are insufficiently evaluated. The four themes below summarise the strong evidence for these general tendencies.

Theme 1: Computational Complexity, Constraints, and Resource Limitations

The first theme established university lecturer timetabling as a computationally demanding allocation problem involving many interdependent decisions. The reviewed studies consistently described university timetabling as NP-hard, indicating that the number of potential schedules increases rapidly with the numbers of courses, lecturers, rooms, student groups, and time slots (Abdipoor et al., 2023b; Yusoff & Roslan, 2019; Adewumi et al., 2009; Davoudzadeh et al., 2009). The studies commonly distinguished between hard constraints,

which determine timetable feasibility, and soft constraints, which determine timetable quality. Frequently reported hard constraints included the prevention of lecturer, room, and student-group conflicts; compliance with lecturer availability; room-capacity requirements; and the assignment of courses to appropriate teaching spaces. Soft constraints included lecturer preferences, the distribution of teaching activities, minimisation of timetable gaps, avoidance of undesirable periods, and reduction of resource wastage (Zunino et al., 2024; Yavuz et al., 2023; Aizam et al., 2019; Babaei et al., 2016). Resource scarcity further restricted the feasible solution space, particularly when institutions had limited classrooms, laboratories, teaching periods, or qualified lecturers (Yavuz et al., 2023; Hidzir & Nordin, 2018). Collectively, the studies represented timetable quality as the combined outcome of constraint satisfaction, resource coordination, and the management of competing institutional requirements.

Theme 2: Mathematical, Heuristic, and Hybrid Solution Approaches

The second theme concerned computational methods for the design or improvement of university timetables. Mathematical programming enabled an explicit representation of decision variables, constraints, and objective functions. Davoudzadeh et al. (2009) proposed a linear model to schedule courses, lecturers, locations, and semester periods whereas Aizam et al. (2019) presented a more general course-timetabling model incorporating constraints derived from practical university settings. Graph-based and heuristic approaches offered alternative mechanisms for handling conflicts and allocating limited time slots (Hidzir & Nordin, 2018; Adewumi et al., 2009). Genetic algorithms were the most utilized among the metaheuristic family, with emphasis on repair or rectification strategies, generalized problem formulations, and fuzzy constraint handling (Lam et al., 2025; Chong-Keat et al., 2015; Ahmad et al., 2012). Hybridization was used to combine the broad search capability of genetic algorithms with the refinement capability of local-search procedures. Yusoff and Roslan (2019) reported better performance of a hybrid genetic algorithm–hill-climbing with elitism as compared to a pure genetic algorithm. The review studies similarly identified that metaheuristics and hybrid metaheuristics were the dominant approaches to handle huge solution spaces and various constraint structures (Abdipoor et al., 2023b; Alghamdi et al., 2020; Hosny, 2019).

Theme 3: Lecturer Preferences, Automation, and User-Oriented Systems

The third theme reflected increasing attention to lecturers as stakeholders in timetable development. Several studies incorporated lecturer availability or preferred teaching periods into the problem formulation rather than treating lecturers only as resources assigned to courses. Babaei et al. (2016) used fuzzy c-means clustering to coordinate lecturers shared among departments, with the reported objectives of improving lecturer satisfaction and reducing interdepartmental resource loss. Lam et al. (2025) combined hard constraints with fuzzy representations of lecturer-related requirements when assigning teaching tasks, whereas Zunino et al. (2024) developed an automated formulation focused specifically on professor-to-course assignment and preferences for time slots. Automation was consistently associated with reducing the time and effort required for manual timetable preparation (Zunino et al., 2024; Hosny, 2019). User-oriented development also appeared in the proposal by Álvarez et al. (2014), which combined a timetabling algorithm with a flexible interface intended to represent institution-specific conditions. Across this theme, the literature operationalized lecturer considerations mainly through availability, preference satisfaction, shared teaching assignments, and compatibility between lecturers and courses. Broader measures of workload distribution, timetable fairness, or lecturer well-being were less frequently represented.

Theme 4: Scalability, Adaptability, Benchmarking, and Future Development

The fourth theme addressed whether proposed approaches could operate across larger, more diverse, and institutionally specific problems. Models developed for one university cannot always be transferred directly to another because institutions differ in constraints definitions, curricula, room structures and scheduling policies (Ahmad et al., 2012; Aizam et al., 2019; Lam et al., 2025). Behuet et al. (2024), for example, developed a data schema, rule language, and toolchain for representing different educational timetabling problems as constraint-satisfaction models. Benchmark datasets and international competitions offer a complementary basis for standardized evaluation (Abdipoor et al., 2023a; Müller et al., 2018). Across the sample, future directions included richer institutional constraints, hybrid methods, improved preference modelling, scalable procedures, practical interfaces, and closer alignment between benchmark problems and operational university requirements.

Cross-Theme Synthesis and Link to the Review Questions

The four themes form a connected pattern across the evidence. The first dominant trend is the persistence of feasibility-oriented modelling such as combinatorial complexity, constraint conflicts, and scarce resources define the problem, while mathematical, graph-based, heuristic, metaheuristic, and hybrid methods provide the main technical responses. The second is growing methodological flexibility through hybrid search, fuzzy constraints, automation, configurable rule languages, and richer benchmarks. The third is an incomplete shift toward stakeholder-centred scheduling. Evidence for this shift comes from studies that explicitly model shared lecturers and satisfaction (Babaei et al., 2016), fuzzy lecturer requirements and preferences (Lam et al., 2025), professor assignment and preferred time slots (Zunino et al., 2024), and adaptable user interfaces or rule-based frameworks (Álvarez et al., 2014; Behuet et al., 2024). However, these studies remain a minority, and lecturer considerations are usually represented as availability or isolated preference constraints rather than validated measures of workload balance, equitable allocation, or overall timetable fairness. Accordingly, RQ1 identified complexity, competing constraints, resource scarcity, manual workload, and limited transferability as the principal challenges. RQ2 identified mathematical, graph-based, heuristic, metaheuristic, hybrid, fuzzy, and automated approaches. RQ3 showed that future work must strengthen scalability, institution-specific adaptation, lecturer-preference integration, workload and fairness evaluation, real-world validation, and usable decision-support interfaces.

Table 1: Summary of the Studies

Authors/year	Sector/context	Study focus	Challenges	Solutions	Future directions	Method/approach	Main contribution	Relevance to review
Babaei et al. (2016)	University departments; lecturers shared across departments	Coordination and preference handling for common lecturers	Coordinating shared lecturers across departments; time-consuming recurrent scheduling.	Cluster shared lecturers and coordinate departmental schedules using clustering and traversing agents.	Improve scalability and preference satisfaction for interdepartmental lecturer scheduling.	Fuzzy c-means clustering with clustering and traversing agents	Provides a scalable coordination approach intended to improve shared-lecturer satisfaction and reduce interdepartmental resource loss.	Directly addresses lecturer preferences and cross-department scheduling.
Davoudzadeh et al. (2009)	University semester scheduling; institution not specified	Assignment of courses, lecturers, locations, and time periods	NP-hard assignment of courses, lecturers, locations, and semester periods.	Represent the assignment problem through a linear formulation.	Not stated in the exported record.	Linear formulation implemented in GLPG	Formalizes the NP-hard university timetabling problem as a linear model.	Establishes a mathematical-programming foundation for lecturer-course scheduling.
Abdipoor et al. (2023b)	University course timetabling; benchmark-oriented literature	Classification and assessment of metaheuristic and hybrid methods	Large solution spaces, numerous constraints, and NP-hard computational complexity.	Apply metaheuristic and hybrid metaheuristic search methods.	Address identified methodological gaps and advance hybrid metaheuristic research.	Comprehensive systematic review	Synthesizes, categorizes, and critically compares metaheuristic approaches and identifies gaps and future work.	Provides the principal comparative evidence base for solution methods.

Authors/year	Sector/context	Study focus	Challenges	Solutions	Future directions	Method/approach	Main contribution	Relevance to review
Chong-Keat et al. (2015)	Faculty department at a Malaysian university; previously manual scheduling	Construction of a feasible lecturer-course timetable	Manual faculty scheduling and difficulty maintaining feasible lecturer-course-room assignments.	Repair infeasible genetic-algorithm schedules through a rectification strategy.	Not stated in the exported record.	Genetic algorithm with rectification strategy	Introduces a repair mechanism for producing feasible schedules in a real faculty setting.	Links computational feasibility with replacement of manual timetable preparation.
Lindahl et al. (2018)	University planning across operational, tactical, and strategic levels	Effects of room and teaching-period decisions on timetable quality	Room and teaching-period decisions made before operational scheduling affect timetable quality.	Optimize and compare strategic, tactical, and operational planning decisions.	Integrate upstream room and teaching-period decisions with operational timetabling.	Strategic optimisation and comparative analysis	Extends timetabling beyond operational assignment to antecedent room and teaching-period decisions.	Broadens the review from algorithms to institutional planning decisions.
Yusoff & Roslan (2019)	Lecturer timetabling using real datasets; institution not specified	Comparison of GA and hybrid GA-hill climbing under hard and soft constraints	Simultaneous hard and soft constraints involving lecturers, students, space, and time.	Combine genetic search, hill climbing, and elitism.	Not stated in the exported record.	Genetic algorithm and hybrid GA-hill climbing with elitism	Reports superior solution performance for the hybrid method relative to the GA comparator.	Offers direct comparative evidence for lecturer-focused hybrid optimisation.
Aizam et al. (2019)	University course timetabling; real-problem constraint orientation	Extension of a general model with overlooked and additional soft constraints	Existing formulations omit constraints and soft requirements found in real settings.	Extend mixed-integer modelling with overlooked and additional soft constraints.	Expand general models with institutionally demanded constraints.	Mixed-integer linear programming model and comparison	Develops a more general formulation incorporating constraints identified from practical settings.	Supports analysis of model completeness and institutional applicability.

Authors/year	Sector/context	Study focus	Challenges	Solutions	Future directions	Method/approach	Main contribution	Relevance to review
Alghamdi et al. (2020)	University timetable scheduling across lecturers, students, rooms, and laboratories	Review of optimisation algorithms applicable to timetable construction	Complex coordination of hours, subjects, lecturers, students, classrooms, and laboratories.	Use optimisation algorithms suited to complex university scheduling.	Not stated in the exported record.	Narrative review of optimisation algorithms	Summarizes algorithmic options for managing complex university scheduling requirements.	Provides broad coverage of established computational solution families.
Hidzir & Nordin (2018)	University scheduling with lecturer, room, and course-section conflicts	Minimisation of the timetable timeframe without conflicts	Lecturer, room, and course-section conflicts within a fixed set of time slots.	Model conflicts through vertex and edge colouring.	Not stated in the exported record.	Vertex- and edge-colouring method	Represents scheduling conflicts graphically to allocate activities across a reduced timeframe.	Adds a graph-theoretic alternative to mathematical and metaheuristic methods.
Behuet et al. (2024)	Educational timetabling across course scheduling and student sectioning	Expression and classification of varied timetabling problem classes	Heterogeneous timetabling problem classes are difficult to model consistently.	Use a data schema, rule language, feature model, and CSP compilation toolchain.	Extend reusable rule-based modelling across additional problem classes.	Rich data schema, rule language, feature model, and CSP compilation toolchain	Provides a configurable modelling language and classifier for diverse timetabling problems.	Addresses model generality, extensibility, and institution-specific constraints.
Hosny (2019)	University examinations, courses, projects, and faculty load; Middle Eastern cases	Review and application of metaheuristics to multiple university scheduling problems	Manual scheduling consumes time and effort across courses, examinations, projects, and faculty load.	Automate different timetabling tasks using heuristics and metaheuristics.	Increase automation and stakeholder satisfaction across scheduling tasks.	Review with institutional case studies	Shows how heuristic automation can reduce manual effort and address different timetabling problem types.	Connects algorithmic methods with stakeholder and regional institutional contexts.

Authors/year	Sector/context	Study focus	Challenges	Solutions	Future directions	Method/approach	Main contribution	Relevance to review
Ahmad et al. (2012)	University environments extending the ITC 2007 problem	Generalization of benchmark timetabling through added practical constraints	Benchmark formulations do not capture all constraints arising across university environments.	Extend the ITC 2007 model with ten practical constraints and solve it using GA.	Develop more general models grounded in varied university environments.	Mathematical model solved by genetic algorithm	Adds ten constraints derived from university environments to improve model generality.	Demonstrates movement from narrow benchmarks toward richer institutional models.
Yavuz et al. (2023)	Industrial Engineering Department, Izmir Bakircay University, Turkey	Assignment of days, hours, and classrooms under limited room availability	Increasing courses and students combined with very limited classroom availability.	Optimize days, hours, and room assignments while minimising classroom usage.	Not stated in the exported record.	Institutional course-timetabling optimisation case study	Addresses growing scheduling complexity and classroom scarcity through room-usage minimisation.	Provides evidence on resource limitations and operational application.
Lam et al. (2025)	Lecturer teaching assignment; institution-specific case characteristics	Assignment by expertise and lecturer wishes under hard and fuzzy constraints	Unique institutional conditions and complex expertise, hard-constraint, and lecturer-wish requirements.	Combine genetic search with hard and fuzzy lecturer-assignment constraints.	Adapt lecturer assignment models to institution-specific requirements.	Genetic algorithm with fuzzy constraints	Combines mandatory teaching-assignment requirements with flexible lecturer preferences.	Directly represents lecturer-centred constraints and context-specific scheduling.
Adewumi et al. (2009)	University lecture timetabling, with emphasis on resource-constrained developing-country institutions	Placement of limited resources into time slots as course numbers grow	Course growth without corresponding resource growth increases scheduling difficulty.	Apply a constructive/dynamic heuristic with predictable performance.	Maintain scalability as course demand grows under constrained resources.	Constructive/dynamic heuristic approach	Proposes a heuristic response to increasing course demand without corresponding resource growth.	Highlights scalability and resource scarcity in a distinct institutional context.

Authors/year	Sector/context	Study focus	Challenges	Solutions	Future directions	Method/approach	Main contribution	Relevance to review
Abdipoor et al. (2023a)	ITC 2019 university course timetabling with student sectioning	Review of competition approaches and the research-practice gap	Research-practice gap, limited solver generality, and inconsistent problem definitions.	Classify and compare methods developed for ITC 2019 with student sectioning.	Improve solver generality, problem-definition consistency, and real-world transferability.	Systematic literature review and approach classification	Synthesizes ITC 2019 methods and documents solver generality and problem-definition consistency issues.	Supports assessment of benchmarking, scalability, and real-world transferability.
Müller et al. (2018)	International benchmark development using real-world university datasets	Existing research, emerging challenges, and design of ITC 2019	Need for complex, practice-derived problems and comparable real-world datasets.	Develop ITC 2019 and its rich, real-world UniTime datasets.	Promote research using richer real-world datasets and standardized competition benchmarks.	Field overview and competition/benchmark design	Motivates richer practical datasets and standardized comparison through ITC 2019.	Establishes the role of international benchmarking in future research.
Zunino et al. (2024)	Small universities in Uruguay, with potential South American applicability	Professor-course assignment incorporating time-slot preferences	Manual professor assignment is labour-intensive and difficult as problem size increases.	Automate professor-course assignment while representing time-slot preferences.	Assess applicability beyond small Uruguayan universities and test alternative solution methods.	Automated post-enrolment-guided formulation with student groups	Automates professor assignment while explicitly representing professor time preferences.	Provides a recent lecturer-centred application and practical automation case.
Álvarez et al. (2014)	University-specific real-world scheduling environments	Integration of a robust algorithm with an adaptable user interface	Existing solutions often address only part of the problem and insufficiently reflect institution-specific constraints.	Combine a robust timetabling algorithm with an adaptable user interface.	Increase usability and adaptability to university-specific constraints.	Algorithm-user-interface framework	Proposes a usable interface capable of representing constraints that vary by university.	Addresses usability, flexibility, and the research-to-practice interface.

Table 1 consolidates the 19 included studies by institutional context, study focus, reported challenges, proposed solutions, future directions, methodological approach, main contribution, and relevance to the review. This comparative overview shows the chronological movement from feasibility-oriented mathematical and heuristic formulations toward hybrid optimisation, lecturer-preference modelling, automated systems, configurable frameworks, and real-world benchmarking. It also provides the descriptive basis for the Discussion section, where the implications of these patterns are examined in relation to the review questions.

Discussion

This review adds to the literature on university timetabling by synthesizing findings from the fields of operations research, computer science, artificial intelligence, educational management, and institutional planning. Its main contribution is in demonstrating that lecturer timetabling is not merely a technical allocation problem. Three findings are especially important. First, the model design and evaluation are still dominated by feasibility and constraint satisfaction. Second, the use of flexible algorithms and hybrid methods has increased the potential to find solutions, but institution-specific datasets and definitions limit the ability to compare and transfer. Third, recent preference-aware and adjustable systems point to a trend toward stakeholder-centred scheduling. However, direct evaluation of workload balance, fairness, lecturer acceptability and sustained institutional use remains uncommon. This synthesis connects computational development to institutional and human effects of timetable design.

The findings reveal that, in relation to the first review issue, the timetabling of university lecturers is influenced by a combination of computational, operational, and institutional challenges. In the computational domain, the problem is always classified as NP-hard and the solution space expands exponentially with the growth in the numbers of courses, lecturers, rooms, student groups, and periods (Abdipoor et al., 2023b; Adewumi et al., 2009; Davoudzadeh et al., 2009). In the operational domain, timetable developers are required to satisfy hard constraints such as no conflict for lecturers, rooms, and student groups and also soft constraints such as lecturer preferences, timetable gaps, undesirable periods, and resource utilization (Aizam et al., 2019; Yusoff & Roslan, 2019). Institutionally, the limited rooms and teaching periods, shared lecturers, and inconsistencies in scheduling policies further reduce the transferability of generic solutions (Yavuz et al., 2023; Babaei et al., 2016). These findings indicate that computational complexity cannot be separated from the organizational context in which the timetable is developed.

As for the second review question, the literature shows a broad range of approaches, but none is consistently better across institutional settings. Mathematical programming offers transparent representations when requirements can be properly defined (Aizam et al., 2019; Davoudzadeh et al., 2009). Graph-colouring and constructive heuristics provide alternative mechanisms for resolving conflicts (Hidzir & Nordin, 2018; Adewumi et al., 2009), while genetic algorithms and other metaheuristics can search large solution spaces without exhaustive enumeration (Abdipoor et al., 2023b; Chong-Keat et al., 2015). Hybrid approaches combine a wide inquiry with a local refining (Yusoff and Roslan, 2019). Therefore, the appropriateness of a method is determined by the problem scale, constraint structure, the quality of solution required, the computational resources available and institutional objectives.

The third review question concerned about limitations, research gaps, and future directions. Evidence from fuzzy clustering, fuzzy lecturer constraints, automated lecturer assignment, flexible interfaces, and configurable rule languages supports a gradual transition from feasibility-centred optimisation to more adaptable and stakeholder-responsive scheduling (Lam et al., 2025; Behuet et al., 2024; Zunino et al., 2024; Babaei et al., 2016; Álvarez et al., 2014). The transition should not be overstated. Most studies still assess feasibility, computational time, or aggregate objective values, and only a small subset explicitly models lecturer preferences. Even fewer consider the fairness of teaching loads, undesirable periods, or timetable gaps, whether lecturers perceive the outcomes are fair, or whether a model is still valid across institutions. Scalability is still a challenge, as deeper preference and fairness criteria increase the size of the search field. The adaptability remains unresolved because universities use different curricula, room structures, policies, and penalty priorities. Fairness and workload balance remain unresolved because shared definitions and validated measures are largely absent. Hence, algorithmic sophistication has outpaced human-centred validation and organizational integration.

Theoretically, university lecturer scheduling should be seen as a multilevel socio-technical optimisation problem. Conventional models are based on the allocation of teaching activities to rooms and periods. However, the quality of a timetable is also shaped by strategic and tactical decisions regarding teaching-space availability, staffing, course offerings, and structure of teaching-periods (Lindahl et al., 2018). The generated timetable is then examined by the lecturers and administrators for its practicality and may request revisions. A comprehensive model should therefore connect strategic resource planning, operational allocation, stakeholder preferences, and post-generation evaluation. The quality of a timetable is multidimensional. Feasibility, efficiency, preference satisfaction, workload balance, adaptability, and fairness are linked but distinguishable outcomes.

The findings have practical implications for the acquisition, design, and evaluation of scheduling systems for universities. The review can be used as a requirements framework for universities. A system should generate conflict-free schedules efficiently, encapsulate local institutional constraints, differentiate between mandatory lecturer availability and desirable preferences, allocate workload indicators and undesirable periods transparently, and support rapid revision when enrolment, staffing, or room availability change. Administrators should define measurable criteria for workload balance, gaps, consecutive classes, preference satisfaction, and undesirable slots and the priority or weight of these criteria and test the model before implementation using several semesters of local data. The results obtained from the pilot run should next be discussed with the lecturers and the timetable administrators to decide whether the revised objective values lead to acceptable timetable. Preference-aware, workload-balanced, and adaptable systems should also keep an auditable explanation of constraint violations and manual overrides. These approaches would assist universities to transfer algorithmic performance into actionable and fair scheduling practice (Zunino et al., 2024; Hosny, 2019; Álvarez et al., 2014).

Several tensions and inconsistencies remain evident in the literature. First, the trade-off between generality and contextual accuracy. While highly general models are good for reuse, institution-specific models can better reflect local requirements (Ahmad et al., 2012; Aizam et al., 2019; Behuet et al., 2024). Second, there is trade-off between computational efficiency and representational richness. More lecturer preferences and policy conditions may increase practical relevance but also enlarge the search space and make it harder to justify objective

weights. The third inconsistency is evaluation. Direct comparison is not easy as the studies use different datasets, constraint definitions, penalty structures, and performance measures. International competitions have improved the standardization, but benchmark cases cannot reflect the organizational variety of universities (Abdipoor et al., 2023a; Müller et al., 2018). Most crucially, the literature rarely evaluates whether favourable aggregate objective values align with lecturers' perceptions of reasonable or fair schedules.

Future research should pursue both computational and human-centred development paths. Computationally, the exploration of hybrid and multi-objective approaches that can balance feasibility, resource utilization, lecturer preferences, workload distribution, and timetable stability should be considered. Institutionally, configurable models should be tested across multiple universities to determine which constraints are transferable and which require local adaptation. Future studies should also develop explicit measures of lecturer-centred timetable quality, including the distribution of undesirable periods, gaps between classes, consecutive teaching assignments, and preference satisfaction. These measures should be validated against lecturers' perceptions rather than assumed to represent fairness automatically. Furthermore, longitudinal implementation studies are needed to examine user adoption, timetable changes, administrative overhead and scheduling results across successive semesters. Finally, shared datasets should allow access to more data on lecturers, whilst protecting their privacy, and thus increase the benchmarking benefits shown by international timetabling competitions (Abdipoor et al., 2023a; Müller et al., 2018).

Several limitations should be considered. First, the evidence base was drawn only from Scopus and comprised 19 eligible studies, so relevant publications indexed elsewhere may have been missed. Second, the English-language restriction may have excluded institution-specific work in other languages. Third, variation in problem definitions, datasets, constraints, and performance measures prevented statistical meta-analysis and limited direct comparison.

Fourth, several records had little information on institutional context or future research. Finally, broader course timetabling studies were included if they incorporated relevant lecturer-related components, although relatively few publications dealt with lecturer timetabling as a separate problem. This decision extended conceptual coverage but required careful distinction between general scheduling evidence and research that was explicitly lecturer centred.

This review concludes that the movement of university lecturer timetabling away from the simple generation of conflict free schedules, is not yet complete. Future systems should be evaluated on five explicit dimensions: operational efficiency, lecturer workload balance, preference satisfaction, fair distribution of undesirable assignments, and compliance to institution-specific constraints. Scalable multi-objective methods, flexible models, transparent decision rules and validation with institutional data and lecturer input can contribute to reach this balance. Connecting these factors would allow universities to develop timetables that are computationally feasible, operationally efficient, adaptable to local requirements, and clearly fairer to lecturers.

Conclusion

This review provides a systematic presentation of the research on university lecturer timetabling and presents the main challenges, solution approaches, and future directions. It treated lecturer timetabling as part of the broader university course-timetabling domain while

focusing on lecturer availability, preferences, teaching assignments, interdepartmental coordination, workload patterns, and undesirable scheduling arrangements.

The reviewed literature demonstrates that lecturer timetabling continues to be a challenging issue due to combinatorial complexity, competing hard and soft constraints, limited institutional resources, and heterogeneity in university policy. Three findings outlined in this review. First, feasibility and constraint satisfaction remain the dominant objectives, which genetic algorithm, hybrid, fuzzy, and automated methods provide increasing computational flexibility. Second, lecturer-centred evaluation has not developed at the same pace. Third, workload balance, preference satisfaction, fairness, institutional adaptability, and stakeholder acceptance are still rarely assessed together or validated across universities.

The main contribution of this review is an integrated view of computational, institutional, and lecturer-centred evidence. It clarifies that the evaluation of the timetable systems by the universities should be carried out not only in terms of running time or free of conflicts but also in terms of operational efficiency, workload allocation, lecturer preferences, fair assignment of undesirable periods and local constraints. Such framework can guide the development, acquisition, and pilot evaluation of preference-aware, workload-balanced, and adaptable scheduling systems.

A key outstanding issue is the minimal adoption of validated indicators of lecturer workload, preference satisfaction, timetable fairness, and perceptions of schedule quality. Future work should combine advanced optimisation with transparent indicators that can be validated cross-institutionally and assessed directly by stakeholders. Such work can be a basis for systems that are not only conflict-free and efficient, but also adaptable, explainable and fair

-
- Acknowledgements:** The authors would like to express their sincere gratitude to University Teknologi MARA Kedah Branch for providing the necessary resources and support throughout the course of this research. Special appreciation is extended to colleagues and peers who contributed valuable insights and constructive feedback, which greatly enhanced the quality of this paper.
- Funding Statement:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
- Conflict of Interest Statement:** The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have contributed to this work and approved the final version of the manuscript for submission to the International Journal of Information System and Technology Management (JISTM).
- Ethics Statement:** This study did not involve any human participants, animals, or sensitive data requiring ethical approval. The authors confirm that the research was conducted in accordance with accepted academic integrity and ethical publishing standards.
- Author Contribution Statement:** All authors contributed significantly to the development of this manuscript. [Author A] was responsible for the conceptualization, methodology, and overall supervision of the study. [Author B] handled data collection, analysis, and interpretation of results. [Author C] contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.
- Declaration on the Use of Artificial Intelligence (AI)** “The author(s) declare that generative AI or AI-assisted technologies were used during the preparation of this manuscript. The following tool(s) were used: ChatGPT and Quillbot. The tool(s) were used for support language refinement and improve the clarity and organization of the manuscript. All AI-assisted content was reviewed and verified by the author(s), who take full responsibility for the accuracy, originality, integrity, and final content of the manuscript.”
-

References

- Abdipoor, S., Yaakob, R., Goh, S. L., Abdullah, S., Kasmiran, K. A., & Hamdan, H. (2023a). International Timetabling Competition 2019: A systematic literature review. In *2023 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS 2023)* (pp. 22–27). IEEE.
- Abdipoor, S., Yaakob, R., Goh, S. L., & Abdullah, S. (2023b). Meta-heuristic approaches for the university course timetabling problem. *Intelligent Systems with Applications*, 19, Article 200253.
- Adewumi, A. O., Sawyerr, B. A., & Montaz Ali, M. (2009). A heuristic solution to the university timetabling problem. *Engineering Computations*, 26(8), 972–984.
- Ahmad, M., Caux, C., & Gourgand, M. (2012). Generic model for university course timetabling problem solved by genetic algorithm. In *Proceedings of the 10th International Industrial Simulation Conference 2012* (pp. 209–216).
- Aizam, N. A. H., Aziz, N. L. A., & Zaulir, Z. M. (2019). New general university course timetabling model towards real problems: A comparison. *Journal of Advanced Research in Dynamical and Control Systems*, 11(12 Special Issue), 244–257.
- Alghamdi, H., Alsubait, T., Alhakami, H., & Baz, A. (2020). A review of optimization algorithms for university timetable scheduling. *Engineering, Technology & Applied Science Research*, 10(6), 6410–6417.
- Álvarez, C. G. P., Reynaga, L. M., Rocha, M. A. M., & Martínez, J. F. (2014). Building an easy to use flexible university timetabling user interface. In *Proceedings of the ACM International Conference* (Article a75). Association for Computing Machinery.
- Babaei, H., Karimpour, J., & Oroji, H. (2016). Using fuzzy c-means clustering algorithm for common lecturers timetabling among departments. In *2016 6th International Conference on Computer and Knowledge Engineering (ICCCKE)* (pp. 243–250). IEEE.
- Behuet, C., Barichard, V., Genest, D., Legeay, M., & Lesaint, D. (2024). A rule language and feature model for educational timetabling. In *Proceedings of the 14th International Conference on the Practice and Theory of Automated Timetabling* (pp. 66–98).
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Chong-Keat, T., Wibowo, A., & Ngadiman, S. (2015). A rectification strategy in genetic algorithms for academic timetabling problem. *Jurnal Teknologi*, 74(1), 159–163.
- Davoudzadeh, M., Rashidi, R., & Rafeh, R. (2009). A linear solution for the university timetabling problem. In *2009 International Conference on Computer and Electrical Engineering* (Vol. 2, pp. 54–57). IEEE.
- Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and open synthesis. *Campbell Systematic Reviews*, 18(2), Article e1230. <https://doi.org/10.1002/cl2.1230>
- Hidzir, N. B., & Nordin, S. Z. B. (2018). Vertex and edge coloring method for timetabling problem in minimizing the time frame. *AIP Conference Proceedings*, 1974, Article 020074.
- Hosny, M. (2019). Metaheuristic approaches for solving university timetabling problems: A review and case studies from Middle Eastern universities. *Smart Innovation, Systems and Technologies*, 111, 10–20. https://doi.org/10.1007/978-3-030-03577-8_2
- Kitchenham, B., & Charters, S. (2007). *Guidelines for performing systematic literature reviews in software engineering* (EBSE Technical Report EBSE-2007-01). Keele University and Durham University.

- Lam, V. T., Minh, N. D., Lan, N. N., & Hung, P. D. (2025). Scheduling for lecturers using genetic algorithm with fuzzy constraints. *Lecture Notes in Computer Science*, 15557, 293–305. https://doi.org/10.1007/978-3-031-88705-5_25
- Lindahl, M., Mason, A. J., Stidsen, T., & Sørensen, M. (2018). A strategic view of university timetabling. *European Journal of Operational Research*, 266(1), 35–45. <https://doi.org/10.1016/j.ejor.2017.09.022>
- Müller, T., Rudová, H., & Müllerová, Z. (2018). University course timetabling and International Timetabling Competition 2019. In *Proceedings of the 12th International Conference on the Practice and Theory of Automated Timetabling* (pp. 5–31).
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, Article n71. <https://doi.org/10.1136/bmj.n71>
- Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207–222. <https://doi.org/10.1111/1467-8551.00375>
- Yavuz, S., Demirci, Z., Güven, B., Kuleli, Z., Yılmaz, B., & Eliyi, D. T. (2023). A course timetabling problem for classroom usage minimization. *Lecture Notes in Mechanical Engineering*, 543–553.
- Yusoff, M., & Roslan, N. (2019). Evaluation of genetic algorithm and hybrid genetic algorithm-hill climbing with elitist for lecturer university timetabling problem. *Lecture Notes in Computer Science*, 11655, 363–373.
- Zunino, M., Del Valle, S. V., & Gatti, L. (2024). An automated approach to university course timetabling focused on professor assignment. In *2024 50th Latin American Computing Conference (CLEI)*. IEEE