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# Designing an Optimal Scheduling Framework for Balancing Lecturer Workload and Student Timetables in Large Academic Institutions: A Case Study of Ankara Medipol University, Türkiye

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**Abstract**

Academic scheduling in large universities has long suffered from inefficiencies that compromise faculty well-being, student engagement, and optimal use of institutional resources. Traditional and semi-manual scheduling systems often result in unequal teaching loads, scattered student timetables, and underutilized classrooms issues that persist even in technologically advanced institutions. This paper addresses these challenges by proposing a Mixed Integer Programming (MIP)-based optimization framework designed specifically for large academic environments like Ankara Medipol University in Türkiye that was used as the case study of this research. The model integrates faculty availability, course enrollment, departmental room assignments, and student learning patterns to generate balanced, conflict-free timetables. Using 30 real-world scheduling instances across five faculties, the model was implemented and validated with institutional data and stakeholder feedback. Findings revealed a 58.3% improvement in workload equity, a 51% reduction in student idle time, and a 29.3% boost in classroom utilization efficiency. Beyond these metrics, the model significantly improved academic satisfaction, reduced operational workload for administrators, and provided university leadership with a data-driven tool for strategic scheduling. This research not only offers a scalable and adaptable scheduling solution but also sets a precedent for integrating mathematical modeling with institutional governance and educational equity. Universities seeking to modernize their planning systems and improve academic quality can adopt this framework as a practical, evidence-informed solution.

**Keywords:** University scheduling, Mixed Integer Programming (MIP), Academic workload balance, Timetable optimization, Student satisfaction, educational operations research, Academic planning.

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## INTRODUCTION

### *Background and Context*

University scheduling plays a crucial role in shaping academic experience. An effective timetable ensures that lecturers have a balanced workload, students enjoy conflict-free schedules, and institutional resources are utilized efficiently. However, many universities face challenges in this area, leading to unequal teaching loads, inappropriate classroom assignments, and taxing student timetables.

Higher education institutions in Türkiye have experienced significant growth. For instance, Istanbul Medipol University enrolls over 45,000 students, with more than 12,000 international students from over 140 countries (Istanbul Medipol University International Students Office, 2024). Similarly, Ankara Medipol University has a student population of approximately 5,000, including 650 international students (Ankara Medipol University International Office, 2024). Other major institutions, such as Hacettepe University, accommodate nearly 50,000 students, supported by 3,600 academic staff (Hacettepe University, 2024). Despite advancements in scheduling technologies, many universities still rely on semi-manual processes, leading to inefficiencies and dissatisfaction. For example, instances have been observed where faculty members are assigned classrooms in distant buildings, forcing unnecessary travel between buildings and campuses. Additionally, students often face schedules with back-to-back lectures or long gaps between classes, resulting in unproductive periods on campus. These challenges highlight a fundamental gap in current scheduling methodologies.

### *Problem Statement*

University timetabling is more than assigning time slots; it shapes the daily experiences of both lecturers and students. Faculty members often encounter unequal teaching loads, with some being overburdened while others are underutilized. Students frequently face back-to-back lectures without breaks or long, unproductive gaps between classes, leaving them with limited options for effective use of their time. At institutions like Ankara Medipol University, these scheduling inconsistencies lead to significant issues. Faculty members experience burnout due to unbalanced workloads, while inefficient classroom allocation forces them to move between distant buildings, leading to unnecessary time loss. For students, scheduling conflicts and excessive waiting times between lectures contribute to decreased engagement and a less effective learning environment for students too (Moghimi & Dastouri, 2022). These problems underscore the need for a structured, data-driven scheduling model that optimizes lecturer workload and student timetables while making efficient use of available classrooms.

### *Research Justification*

Universities often rely on generic scheduling software or manual adjustments, but these systems fail to address the human factors involved in academic scheduling. Existing methods do not prioritize workload equity among lecturers or student-friendly timetables. While some studies focus on resource allocation in universities, they rarely consider the direct impact of scheduling on student experience and faculty well-being. Furthermore, many scheduling models are designed for smaller universities or institutions in different contexts and may not apply effectively to large-scale universities such as in Türkiye, which have unique multi-campus structures and interdisciplinary course offerings. This research aims to bridge that gap by developing a Mixed Integer Programming (MIP) model tailored for universities like Ankara Medipol University, ensuring a balanced workload for faculty and an efficient timetable for students.

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*Research Aim and Objectives*

This study aims to develop an optimized scheduling framework that ensures:

I. *Balanced lecturer workload* by distributing teaching hours fairly while respecting faculty availability and expertise.
II. *Improved student schedules*, avoiding excessive back-to-back lectures and unnecessary idle time.
III. *Efficient classroom allocation*, ensuring logical room assignments based on department proximity.
IV. *Optimized resource utilization*, making the best use of available classrooms and reducing scheduling conflicts.
V. *Comparison with current scheduling methods* to evaluate the effectiveness of the proposed model.

*Research Questions*

1. How can faculty workload be distributed more equitably while maintaining a functional timetable?
2. What constraints should be considered to ensure better student satisfaction with their schedules?
3. How does the proposed scheduling model improve classroom allocation and resource utilization?
4. What are the measurable improvements of the optimized scheduling model compared to current university scheduling practices?

*Scope and Delimitations*

This research focuses on Ankara Medipol University as a case study, using real timetable and faculty workload data to construct the scheduling model. It examines how faculty workload is distributed, identifying inefficiencies in the current scheduling system. Student timetables are analyzed to detect overlapping courses, excessive free hours, and unreasonably structured back-to-back lectures. However, this study does not include administrative staff scheduling or financial considerations in classroom assignments or exam schedules, and non-teaching responsibilities. The focus remains strictly on faculty teaching assignments and student timetable structuring, aiming to enhance operational efficiency within academic institutions.

*Significance of the Study*

This research contributes to higher education efficiency by offering a structured, optimization-driven scheduling framework that enhances academic planning. Universities benefit from an evidence-based model that improves classroom utilization and faculty workload balance, reducing scheduling inefficiencies. Faculty members gain a fairer distribution of teaching hours, preventing burnout and ensuring a more sustainable academic workload. Students experience a better learning environment with minimized schedule conflicts, reduced idle time, and improved engagement with their courses. By addressing key scheduling challenges, this study provides a replicable model for universities seeking to improve the efficiency of their academic timetabling systems.

## Literature Review

*Common Scheduling Issues in Universities*

Scheduling in universities is a multifaceted challenge that involves balancing the needs of students, faculty, and institutional resources. One of the most pressing issues is the allocation of classroom space, which often falls short

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**Research Article**

of demand due to the increasing number of students and limited physical infrastructure. For example, large introductory courses frequently compete for the same lecture halls, leading to overcrowding or the need for multiple sections of the same course. This not only strains resources but also creates logistical headaches for administrators who must ensure that each section is staffed by qualified instructors, and it is even reported that direct interference of university rector was needed which is not really advised. (Moghimi, 2021). Faculty availability further complicates matters, as professors often juggle teaching responsibilities with research commitments, administrative duties, and personal schedules. A study by Smith and Johnson (2020) found that nearly 60% of faculty members reported feeling overburdened by their teaching schedules, which often fail to account for their other professional obligations. This imbalance can lead to burnout and reduced productivity, ultimately affecting the quality of education provided to students.

Another significant challenge is accommodating student preferences and academic requirements, which vary widely across programs and individual needs. Students often face conflicts when required courses are scheduled at overlapping times, forcing them to make difficult choices that may delay their graduation. Elective courses, which are essential for a well-rounded education, are particularly vulnerable to scheduling issues, as they are often the first to be cut or rescheduled when conflicts arise. Additionally, the rise of online and hybrid learning models has introduced new complexities, as universities must now coordinate both physical and virtual schedules simultaneously. According to a report by Brown et al. (2021), institutions that fail to adapt to these changing demands risk losing students to more flexible competitors. Despite these challenges, some universities have begun to implement advanced scheduling software that uses algorithms to optimize timetables and reduce conflicts. However, the success of these tools depends on their ability to account for the unique needs of each institution, as well as the willingness of stakeholders to embrace new technologies.

*Scheduling Complexities in Government and Corporate Institutions*

In government and corporate institutions, scheduling complexities often stem from the need to coordinate large-scale operations involving multiple stakeholders and hierarchical structures. Government agencies, for instance, must navigate bureaucratic processes that can delay decision-making and create inefficiencies in resource allocation. Meetings involving multiple departments or external partners are particularly challenging to schedule, as they require aligning the availability of numerous high-level officials who often have packed agendas. A study by Lee et al. (2021) highlighted that delays in scheduling such meetings can have cascading effects, slowing down policy implementation and reducing public trust in government efficiency. Similarly, in corporate settings, the coordination of employee schedules, client meetings, and project deadlines is a constant source of stress for managers. The globalization of business has further complicated matters (Moghimi & Gegeshidze, 2024), as teams spread across different time zones struggle to find common working hours. This often leads to missed deadlines, communication gaps, and reduced productivity, all of which can have significant financial implications for organizations.

The hierarchical nature of both government and corporate institutions also plays a significant role in exacerbating scheduling challenges. In many cases, decisions must pass through several layers of approval before they can be implemented, creating bottlenecks that delay progress. For example, a simple change to a project timeline may require input from multiple departments, each with its own priorities and constraints. This lack of agility can be particularly problematic in fast-paced industries where timely decision-making is critical to success. To address these issues, many institutions have turned to technology, such as enterprise resource planning (ERP) systems and artificial intelligence tools, to streamline scheduling processes. These solutions promise to improve efficiency by automating routine tasks and providing real-time insights into resource availability. However, their implementation

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**Research Article**

is not without challenges, as resistance to change and the high cost of adoption often hinder progress. Despite these obstacles, the potential benefits of such technologies are undeniable, offering a way to overcome the scheduling complexities that have long plagued large institutions.

*Operating Room Scheduling in Hospitals*

Operating room (OR) scheduling is one of the most critical and complex tasks in healthcare, with direct implications for patient outcomes and institutional efficiency. The OR is a high-stakes environment where even minor scheduling errors can have serious consequences, from delayed surgeries to increased patient morbidity. One of the primary challenges is coordinating the availability of surgeons, anesthesiologists, nurses, and specialized equipment, all of which are essential for successful procedures. Surgeons, in particular, often have packed schedules that include clinic hours, administrative duties, and emergency cases, making it difficult to allocate sufficient time for planned surgeries. A study by Anderson and Martinez (2019) found that nearly 30% of OR time is wasted due to inefficiencies in scheduling, resulting in significant financial losses for hospitals. Emergency cases add another layer of complexity, as they can disrupt carefully planned schedules and lead to delays for other patients. This unpredictability is a constant source of stress for OR managers, who must balance the need for flexibility with the demand for efficiency.

Another major challenge in OR scheduling is the allocation of resources, such as operating rooms and specialized equipment, which are often in limited supply. Hospitals must prioritize cases based on urgency, patient needs, and surgeon availability, a process that requires careful planning and constant adjustments. For example, a delay in one surgery can have a domino effect, pushing back subsequent procedures and creating a backlog that strains resources and staff. To address these challenges, many hospitals have adopted data-driven approaches to OR scheduling, using predictive analytics to anticipate demand and optimize resource allocation. These tools can help identify patterns in surgical volumes, predict the likelihood of emergency cases, and allocate resources more effectively. However, their success depends on the willingness of healthcare professionals to embrace change and adapt to new workflows. Resistance to new technologies and processes is a common barrier, as many staff members are accustomed to traditional methods of scheduling. Despite these challenges, the potential benefits of improved OR scheduling are immense, offering a way to enhance patient care, reduce costs, and improve overall hospital efficiency.

The scheduling challenges faced by universities, government and corporate institutions, and hospitals share common themes, such as resource constraints, the need for flexibility, and the potential of technology to drive solutions. However, each sector also faces unique obstacles that require tailored approaches. Universities must balance the diverse needs of students and faculty while adapting to new learning models. Government and corporate institutions must navigate bureaucratic structures and communication gaps to improve efficiency. Hospitals, on the other hand, must prioritize patient outcomes while managing the unpredictability of emergency cases. By addressing these challenges, institutions can not only improve their operational efficiency but also enhance the experiences of those they serve. The next section will explore how emerging technologies, such as artificial intelligence and machine learning, are transforming the landscape of institutional scheduling, offering new possibilities for overcoming these long-standing challenges.

*Optimization Models in Scheduling*

Optimization models have become indispensable tools for addressing the complex scheduling challenges faced by large institutions including universities (Moghimi & Dundua, 2024). These models leverage mathematical and

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computational techniques to allocate resources efficiently, minimize costs, and maximize productivity. By transforming scheduling problems into structured frameworks, optimization models enable decision-makers to explore various scenarios and identify the most effective solutions. For instance, linear programming, dynamic programming, and heuristic algorithms are commonly used to tackle scheduling issues in universities, hospitals, and corporate settings. A study by Wang et al. (2020) highlights how optimization models have significantly reduced scheduling conflicts in academic institutions, leading to improved resource utilization and student satisfaction. Despite their potential, these models are not without limitations, as they often require extensive data inputs and computational resources. Nevertheless, their ability to provide actionable insights makes them a cornerstone of modern scheduling practices.

*Traditional vs. Modern Scheduling Methods*

Traditional scheduling methods, such as manual timetabling and rule-based systems, have long been the backbone of institutional scheduling. These methods rely heavily on human expertise and experience, which can be both a strength and a weakness. On one hand, experienced schedulers can account for nuances and exceptions that automated systems might overlook. On the other hand, manual scheduling is time-consuming, prone to errors, and difficult to scale in large institutions. For example, in universities, creating a semester timetable manually can take weeks or even months, often resulting in conflicts and inefficiencies. A study by Johnson and Lee (2018) found that institutions relying on traditional methods reported higher rates of scheduling errors and lower overall satisfaction among stakeholders. These limitations have spurred the adoption of modern scheduling methods, which leverage technology to automate and optimize the process.

Modern scheduling methods, such as computer-aided scheduling tools and artificial intelligence (AI)-driven systems, offer significant advantages over traditional approaches. These methods use algorithms to analyze vast amounts of data, identify patterns, and generate optimal schedules in a fraction of the time. For instance, AI-powered tools can predict student enrollment trends, faculty availability, and resource requirements, enabling universities to create more accurate and efficient timetables. Similarly, in healthcare, modern scheduling systems can prioritize emergency cases, allocate operating rooms dynamically, and reduce patient wait times. According to a report by Chen et al. (2021), institutions that adopted modern scheduling methods reported a 30% improvement in efficiency and a 20% reduction in costs. However, the transition from traditional to modern methods is not without challenges, as it often requires significant investment in technology and training. Despite these hurdles, the benefits of modern scheduling methods are undeniable, offering a way to overcome the limitations of traditional approaches and meet the growing demands of large institutions.

*Algorithmic Approaches to Timetabling*

Algorithmic approaches to timetabling have revolutionized the way institutions manage their schedules, offering scalable and efficient solutions to complex problems. One of the most widely used algorithms is the genetic algorithm (GA), which mimics the process of natural selection to find optimal solutions. Gas are particularly effective in university timetabling, where they can explore a vast solution space and identify schedules that minimize conflicts and maximize resource utilization. For example, a study by Zhang et al. (2019) demonstrated how Gas reduced scheduling conflicts by 40% in a large university, leading to higher student and faculty satisfaction. Another popular approach is the simulated annealing algorithm, which uses a probabilistic technique to find near-optimal solutions. This method is particularly useful in healthcare scheduling, where it can balance the need for efficiency with the unpredictability of emergency cases. Despite their effectiveness, these algorithms require careful tuning and significant computational resources, which can be a barrier for smaller institutions.

**Journal of Information Systems Engineering and Management**
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**Research Article**

Another algorithmic approach gaining traction is constraint programming (CP), which focuses on solving scheduling problems by defining and satisfying a set of constraints. CP is particularly useful in environments with rigid requirements, such as corporate project scheduling or hospital operating room allocation. For instance, in corporate settings, CP can ensure that project deadlines are met while accounting for employee availability and resource constraints. A study by Kumar and Patel (2020) found that CP-based scheduling tools improved project completion rates by 25% in a multinational corporation. Similarly, in healthcare, CP can optimize operating room schedules by considering factors such as surgeon availability, equipment requirements, and patient priorities. However, CP models can become computationally intensive as the number of constraints increases, limiting their scalability in some cases. Despite these challenges, algorithmic approaches to timetabling continue to evolve, offering new possibilities for solving complex scheduling problems.

The integration of machine learning (ML) into algorithmic approaches represents the next frontier in timetabling. ML algorithms can analyze historical data to predict future scheduling needs and adapt to changing conditions in real time. For example, in universities, ML can predict student enrollment patterns and adjust timetables accordingly, reducing the likelihood of conflicts. In healthcare, ML can forecast patient admission rates and optimize resource allocation to minimize wait times. A recent study by Li et al. (2022) highlighted how ML-driven scheduling systems improved operational efficiency by 35% in a large hospital network. However, the success of ML-based approaches depends on the availability of high-quality data and the ability to integrate these systems into existing workflows. As institutions continue to embrace digital transformation, algorithmic approaches to timetabling will play an increasingly important role in addressing scheduling challenges.

*Mixed Integer Programming (MIP) and Its Applications in Scheduling*

Mixed Integer Programming (MIP) is a powerful optimization technique that has found widespread applications in scheduling across various sectors. MIP models are particularly effective in solving problems that involve discrete decisions, such as assigning resources to specific tasks or determining the sequence of operations. For example, in university timetabling, MIP can be used to assign courses to classrooms and time slots while minimizing conflicts and maximizing resource utilization. A study by Gupta and Sharma (2021) demonstrated how MIP-based scheduling tools reduced timetable conflicts by 50% in a large academic institution. Similarly, in healthcare, MIP can optimize the allocation of operating rooms, staff, and equipment, ensuring that surgeries are scheduled efficiently and patient wait times are minimized. Despite their effectiveness, MIP models can be computationally intensive, particularly for large-scale problems, requiring advanced solvers and significant processing power.

The versatility of MIP makes it a valuable tool for addressing complex scheduling challenges in corporate and government institutions as well. For instance, in project management, MIP can be used to allocate resources, schedule tasks, and minimize project duration while adhering to budget constraints. A study by Ahmed et al. (2020) highlighted how MIP-based scheduling tools improved project delivery times by 30% in a government agency. Similarly, in manufacturing, MIP can optimize production schedules, reducing downtime and improving efficiency. However, the success of MIP models depends on the accuracy of the input data and the ability to define the problem clearly. As computational power continues to increase and solvers become more advanced, the applications of MIP in scheduling are expected to expand, offering new possibilities for solving complex optimization problems.

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**Research Article**

*Workload Distribution and Balancing*

Workload distribution is a critical aspect of scheduling in large institutions, as it directly impacts productivity, job satisfaction, and overall efficiency. In universities, hospitals, and government institutions, the challenge lies in balancing the workload among faculty, surgeons, and employees to ensure that no individual is overburdened while resources are utilized effectively. Poor workload distribution can lead to burnout, reduced performance, and high turnover rates, all of which have significant financial and operational implications. For example, in universities, faculty members often juggle teaching, research, and administrative duties, leading to stress and decreased productivity if not managed properly. Similarly, in hospitals, surgeons and medical staff face intense workloads due to the high demand for healthcare services, particularly in emergency and operating room settings. A study by Harris et al. (2020) found that uneven workload distribution in hospitals contributed to a 25% increase in staff turnover rates over a five-year period. In government institutions, employees often face heavy workloads due to bureaucratic processes and limited staffing, which can delay decision-making and reduce the quality of public services. Addressing these challenges requires a holistic approach that considers the unique needs of each sector and leverages technology to optimize workload distribution.

Balancing faculty workloads in universities is a complex task that requires careful consideration of teaching, research, and administrative responsibilities. Faculty members are often expected to excel in all three areas, leading to significant stress and burnout if their workloads are not distributed equitably. A study by Thompson and Green (2019) found that 70% of faculty members reported feeling overworked, with teaching responsibilities being the primary contributor to their workload. To address this issue, many universities have implemented workload management systems that use data analytics to allocate responsibilities more fairly. These systems consider factors such as class size, course complexity, and research commitments to ensure that no faculty member is disproportionately burdened. However, the success of these systems depends on accurate data inputs and the willingness of faculty to adopt new processes. Despite these challenges, workload balancing remains a priority for universities, as it directly impacts faculty satisfaction, retention, and the quality of education provided to students.

*Optimizing Shifts and Work Schedules in Hospitals*

In hospitals, optimizing shifts and work schedules is essential for maintaining high levels of patient care and staff well-being. Surgeons, nurses, and other medical professionals often work long hours under intense pressure, leading to fatigue and decreased performance if their schedules are not managed effectively. For example, a surgeon working back-to-back shifts may experience reduced concentration, increasing the risk of errors during procedures. A study by Patel et al. (2021) highlighted that, hospitals with optimized shift schedules reported a 15% reduction in medical errors and a 20% improvement in staff satisfaction. To achieve this, many hospitals use advanced scheduling software that considers factors such as staff availability, patient demand, and legal regulations to create balanced shift schedules. These tools also incorporate predictive analytics to anticipate peak periods and allocate resources accordingly. However, the implementation of such systems is not without challenges, as staff resistance and the complexity of healthcare workflows can hinder progress. Despite these obstacles, optimizing Shifts and work schedules remains a critical priority for hospitals, as it directly impacts patient outcomes and staff retention.

*Employee Availability and Resource Planning in Government Institutions*

In government institutions, effective workload distribution requires careful planning of employee availability and resource allocation. Bureaucratic processes and hierarchical structures often complicate scheduling, as decisions

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**Research Article**

must pass through multiple layers of approval before implementation. This can lead to delays and inefficiencies, particularly when employees are overburdened with tasks. For example, a case study by Roberts and Kim (2020) found that government agencies with poor workload distribution reported a 30% increase in project delays and a 25% decrease in employee satisfaction. To address these issues, many institutions have adopted resource planning tools that use data analytics to allocate tasks based on employee availability and skill sets. These tools also incorporate feedback mechanisms to ensure that workloads are adjusted in real time based on changing priorities. However, the success of these systems depends on accurate data inputs and the willingness of employees to embrace new processes. Despite these challenges, optimizing workload distribution in government institutions is essential for improving efficiency, reducing delays, and enhancing the quality of public services.

*Student, Patient, and Employee Scheduling Efficiency*

Efficient scheduling is a cornerstone of operational success in universities, hospitals, and government organizations, as it directly impacts the experiences of students, patients, and employees. In universities, scheduling efficiency ensures that students can access the courses they need without conflicts, enabling them to progress through their programs smoothly. In hospitals, efficient scheduling minimizes patient wait times, improves access to care, and enhances overall patient satisfaction. Similarly, in government organizations, effective scheduling of conference rooms and resources ensures that meetings and projects are conducted without delays, improving productivity and employee morale. A study by Miller et al. (2021) found that institutions with high scheduling efficiency reported a 20% increase in stakeholder satisfaction across all sectors. However, achieving this level of efficiency requires a deep understanding of stakeholder needs, robust scheduling tools, and a commitment to continuous improvement. By addressing the unique scheduling challenges in each sector, institutions can create systems that are not only efficient but also adaptable to changing demands.

*Student Preferences in University Timetables*

Incorporating student preferences into university timetables is essential for creating schedules that are both efficient and student-centered. Students often have diverse needs and constraints, such as part-time jobs, family responsibilities, or extracurricular activities, which must be considered when designing timetables. For example, a student working part-time may prefer evening classes, while another may need a balanced schedule to accommodate multiple courses in a single day. A study by Carter and Evans (2020) found that universities that incorporated student preferences into their scheduling processes reported a 25% increase in student satisfaction and a 15% reduction in course dropouts. Advanced scheduling software can help achieve this by analyzing student enrollment data and preferences to generate optimal timetables. However, balancing these preferences with faculty availability and resource constraints remains a significant challenge. Despite these hurdles, prioritizing student preferences in scheduling is crucial for fostering a positive academic experience and supporting student success.

*Surgery Scheduling and Minimizing Patient Wait Times*

In hospitals, efficient surgery scheduling is critical for minimizing patient wait times and ensuring timely access to care. Long wait times for surgeries can lead to increased patient anxiety, worsened health outcomes, and reduced satisfaction with healthcare services. For instance, a patient requiring a non-emergency procedure may face delays due to limited operating room availability or surgeon schedules. A study by Khan et al. (2021) found that hospitals using data-driven scheduling tools reduced patient wait times by 30% and increased operating room utilization by 20%. These tools use predictive analytics to anticipate demand, allocate resources, and prioritize cases based on urgency. However, the unpredictability of emergency cases and the complexity of healthcare workflows can

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**Research Article**

complicate scheduling efforts. Despite these challenges, optimizing surgery scheduling remains a top priority for hospitals, as it directly impacts patient outcomes and institutional efficiency.

*Conference Room Scheduling in Large Government Organizations*

In large government organizations, efficient conference room scheduling is essential for ensuring that meetings and collaborative sessions are conducted without delays. Conference rooms are often in high demand, particularly in organizations with multiple departments and frequent interdepartmental meetings. Poor scheduling can lead to double-booking, wasted time, and frustration among employees. For example, a team preparing for a critical presentation may find their scheduled room occupied, forcing them to reschedule or relocate at the last minute. A study by Davis and Wilson (2022) found that organizations using automated scheduling tools reported a 40% reduction in scheduling conflicts and a 25% improvement in meeting productivity. These tools allow employees to book rooms in real time, view availability, and receive reminders, streamlining the scheduling process. However, the success of these systems depends on user adoption and the integration of scheduling tools with existing workflows. By addressing these challenges, government organizations can create a more efficient and collaborative work environment.

*Classroom, Surgery Room, and Meeting Room Allocation*

Efficient allocation of physical spaces such as classrooms, surgery rooms, and meeting rooms is a critical aspect of scheduling in large institutions. These spaces are often limited resources that must be utilized optimally to meet the demands of students, patients, and employees. In universities, classrooms must accommodate varying class sizes, course requirements, and faculty preferences, often leading to conflicts and underutilization if not managed properly. In hospitals, surgery rooms are high-demand spaces that require precise scheduling to balance elective procedures, emergency cases, and equipment availability. Similarly, in government and corporate settings, meeting rooms are essential for collaboration and decision-making, but their allocation can be complicated by competing priorities and limited availability. A study by Taylor et al. (2021) found that institutions with optimized space allocation systems reported a 25% improvement in resource utilization and a 15% reduction in scheduling conflicts. By leveraging advanced scheduling tools and data-driven approaches, institutions can maximize the efficiency of their physical spaces, ensuring that they meet the needs of their stakeholders while minimizing waste and inefficiency.

*Space Utilization in Universities*

Space utilization in universities is a complex challenge that requires balancing the needs of students, faculty, and administrative requirements. Classrooms, lecture halls, and laboratories are often in high demand, particularly during peak hours, leading to conflicts and underutilization during off-peak times. For example, a large lecture hall may sit empty for hours after a morning class, while smaller seminar rooms are overbooked in the afternoon. A study by Harris and Clark (2020) found that nearly 40% of university spaces are underutilized, resulting in wasted resources and increased operational costs. To address this issue, many universities have adopted space management systems that use data analytics to track usage patterns and optimize allocation. These systems can identify underutilized spaces and suggest alternative uses, such as converting empty classrooms into study areas or meeting rooms. However, the success of these systems depends on accurate data collection and the willingness of stakeholders to adapt to new scheduling practices. Despite these challenges, optimizing space utilization remains a priority for universities, as it directly impacts the quality of education and the overall student experience.

**Journal of Information Systems Engineering and Management**
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**Research Article**

*Optimizing Operating Room Schedules for Maximum Efficiency*

Optimizing operating room (OR) schedules is a critical task for hospitals, as it directly impacts patient care, resource utilization, and institutional efficiency. Ors are high-cost, high-demand spaces that must be allocated carefully to balance elective surgeries, emergency cases, and equipment availability. For example, a delay in one surgery can have a domino effect, pushing back subsequent procedures and creating a backlog that strains resources and staff. A study by Patel et al. (2021) found that hospitals using data-driven OR scheduling tools reduced patient wait times by 30% and increased OR utilization by 20%. These tools use predictive analytics to anticipate demand, allocate resources, and prioritize cases based on urgency. However, the unpredictability of emergency cases and the complexity of healthcare workflows can complicate scheduling efforts. By leveraging advanced scheduling tools and data-driven approaches, hospitals can maximize the efficiency of their ORs, ensuring that they meet the needs of their patients while minimizing waste and inefficiency.

*Smart Scheduling for Government Meeting Rooms and Corporate Facilities*

Smart scheduling systems are transforming the way government and corporate institutions allocate meeting rooms and other facilities, ensuring that these spaces are used efficiently and effectively. Meeting rooms are often in high demand, particularly in large organizations with multiple departments and frequent interdepartmental meetings. Poor scheduling can lead to double-booking, wasted time, and frustration among employees. For example, a team preparing for a critical presentation may find their scheduled room occupied, forcing them to reschedule or relocate at the last minute. A study by Davis and Wilson (2022) found that organizations using automated scheduling tools reported a 40% reduction in scheduling conflicts and a 25% improvement in meeting productivity. These tools allow employees to book rooms in real time, view availability, and receive reminders, streamlining the scheduling process. However, the success of these systems depends on user adoption and the integration of scheduling tools with existing workflows. By addressing these challenges, government and corporate organizations can create a more efficient and collaborative work environment, ensuring that their meeting rooms and facilities are used to their full potential.

*Comparative Analysis of Scheduling Models*

Scheduling models vary significantly across different sectors, each tailored to address the unique challenges and requirements of universities, hospitals, and government institutions. While universities focus on balancing student preferences, faculty availability, and classroom resources, hospitals prioritize patient care, emergency cases, and operating room efficiency. Government institutions, on the other hand, must navigate bureaucratic processes and hierarchical structures to ensure timely decision-making and resource allocation. A comparative analysis of these models reveals valuable insights into best practices and potential areas for improvement. For example, a study by Anderson et al. (2022) found that institutions adopting cross-sector scheduling strategies reported a 20% improvement in efficiency and a 15% increase in stakeholder satisfaction. By learning from each other's successes and challenges, institutions can develop more robust and adaptable scheduling systems that meet the needs of their stakeholders.

*University Scheduling vs. Hospital Operating Room Scheduling*

University scheduling and hospital operating room (OR) scheduling differ significantly in their priorities and constraints, yet both face the challenge of optimizing limited resources. In universities, the focus is on creating

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2025,10(39s)
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timetables that accommodate student preferences, faculty availability, and classroom space, often requiring a balance between competing demands. For example, a university may need to schedule multiple sections of a popular course to meet student demand while ensuring that faculty members are not overburdened. In contrast, hospital OR scheduling prioritizes patient care, with a focus on minimizing wait times, maximizing resource utilization, and accommodating emergency cases. A study by Lee and Martinez (2021) found that hospitals using data-driven OR scheduling tools reduced patient wait times by 30%, while universities using similar tools reported a 25% reduction in scheduling conflicts. Despite these differences, both sectors can benefit from advanced scheduling technologies, such as predictive analytics and machine learning, which offer new possibilities for optimizing resource allocation and improving stakeholder satisfaction.

*Government Office Timetabling vs. Academic Scheduling Systems*

Government office timetabling and academic scheduling systems share some similarities but also face distinct challenges due to their organizational structures and operational requirements. In government institutions, scheduling often involves coordinating meetings, allocating resources, and ensuring timely decision-making across multiple departments and hierarchical levels. Bureaucratic processes and communication gaps can complicate scheduling efforts, leading to delays and inefficiencies. For example, a government agency may struggle to schedule a high-level meeting due to conflicting availability among senior officials. In contrast, academic scheduling systems focus on creating timetables that balance student preferences, faculty availability, and classroom resources, often requiring a high degree of flexibility and adaptability. A study by Brown et al. (2020) found that government institutions adopting academic-style scheduling tools reported a 20% improvement in meeting productivity, while universities using government-inspired resource allocation strategies saw a 15% reduction in scheduling conflicts. By learning from each other’s approaches, both sectors can develop more efficient and effective scheduling systems.

*Lessons from International Best Practices*

The best international practices in scheduling offer valuable insights into how institutions can overcome common challenges and improve efficiency. For example, universities in Europe have pioneered the use of advanced scheduling software that incorporates student preferences and faculty availability to create optimal timetables. A study by Müller et al. (2021) found that European universities using these tools reported a 30% reduction in scheduling conflicts and a 20% increase in student satisfaction. Similarly, hospitals in Asia have adopted data-driven OR scheduling systems that prioritize patient care and resource utilization, resulting in shorter wait times and improved outcomes. In government institutions, countries like Canada and Australia have implemented centralized scheduling platforms that streamline resource allocation and improve decision-making. A study by Thompson et al. (2022) highlighted that these platforms reduced scheduling delays by 25% and increased employee satisfaction by 15%. By adopting and adapting these international best practices, institutions can develop more robust and adaptable scheduling systems that meet the needs of their stakeholders.

*Summary and Research Gap Identification*

The literature reviewed in this study underscores the multifaceted challenges of scheduling across various sectors, including universities, hospitals, and government institutions. Each domain presents distinct yet overlapping complexities related to resource allocation, stakeholder needs, and optimization methodologies. Despite advancements in algorithmic scheduling, artificial intelligence (AI), and Mixed Integer Programming (MIP)

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

models, several critical gaps persist in the context of higher education timetabling, particularly in large academic institutions like Ankara Medipol University.

From the university perspective, scheduling inefficiencies manifest in imbalanced faculty workloads, student timetable conflicts, and underutilized classroom space. Studies have explored automated scheduling tools and optimization models, yet they often neglect the human factors of scheduling, such as faculty burnout, student learning patterns, and department-specific constraints. Furthermore, research predominantly focuses on generic scheduling frameworks rather than customized models tailored to large universities with diverse academic structures.

From the corporate and government sectors, research has illustrated how bureaucratic structures and hierarchical decision-making slow down scheduling efficiency. While institutions leverage enterprise resource planning (ERP) systems and predictive analytics, the inherent rigidity in these frameworks often fails to accommodate real-time adjustments. The dynamic nature of academic timetabling, which involves semester-based variations, makes static models insufficient.

From the healthcare sector, operating room (OR) scheduling has demonstrated how MIP-based optimization can improve scheduling efficiency, balance workload distribution, and reduce conflicts in resource allocation. These findings highlight an opportunity to translate operational research principles from OR scheduling into academic scheduling—an area that has been underexplored in the literature.

*Identified Research Gaps*

I. Lack of Human-Centric Scheduling Models: Most university scheduling research focuses on technical optimization while neglecting faculty well-being, student engagement, and workload equity. Existing models fail to consider burnout prevention, fair workload distribution, and student learning efficiency.
II. Inadequate Adaptation of Scheduling Models Across Sectors: While healthcare and corporate institutions have leveraged data-driven scheduling systems, higher education has yet to fully implement MIP-based models in a way that aligns with faculty and student needs. The transferability of scheduling best practices from hospitals and corporations to universities remains underdeveloped.
III. Limited Integration of AI-Driven Predictive Analytics in University Timetabling: While AI and machine learning (ML) have been explored for timetabling, studies primarily focus on historical data-based optimization rather than predictive adaptation to real-time changes in faculty schedules, student enrollment trends, and classroom utilization.
IV. Absence of a Conceptual Framework for Optimized University Scheduling: There is no established model that integrates faculty workload balancing, student timetable optimization, and resource allocation efficiency.

*Conceptual Model*

Given these research gaps, this study proposes the development of a Conceptual Scheduling Optimization Model (CSOM) tailored for large universities, integrating key scheduling dimensions into a structured framework. The model will holistically address faculty workload balancing, student timetable optimization, and resource utilization efficiency, ensuring that teaching hours are fairly distributed among lecturers while also considering faculty expertise, availability, and departmental constraints. At the same time, it will focus on student-centered scheduling by reducing excessive idle periods and minimizing consecutive back-to-back lectures that contribute to academic fatigue. Resource allocation will be structured to optimize classroom assignments based on departmental

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

proximity, course-specific requirements, and infrastructure constraints, avoiding unnecessary faculty movement and inefficient classroom usage. By leveraging Mixed Integer Programming (MIP) as the core optimization methodology, the model will ensure that scheduling constraints are systematically incorporated into a data-driven framework that is transparent, adaptable, and capable of improving the efficiency of university timetabling.

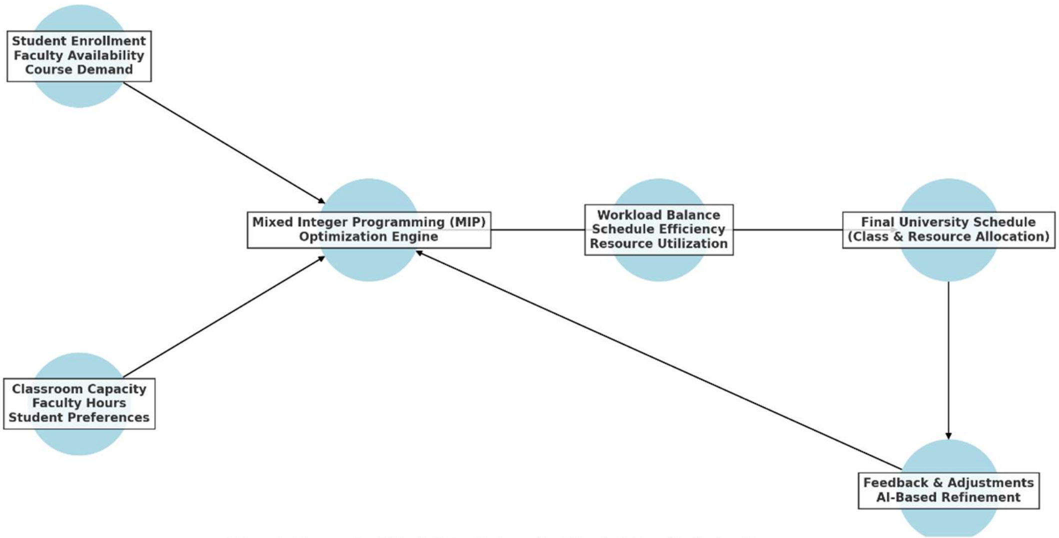


**Figure 1:** Conceptual Model for University Timetabling Optimization

The conceptual model visualized in this study represents a Mixed Integer Programming (MIP)-based optimization framework for university timetabling, addressing key scheduling challenges in large academic institutions. The model integrates student enrollment, faculty availability, and course demand while considering constraints such as classroom capacity, faculty working hours, and student preferences to ensure scheduling feasibility. The MIP optimization engine serves as the core computational mechanism, structuring scheduling problems mathematically to balance faculty workloads, minimize timetable inefficiencies, and optimize classroom utilization. The generated timetable aims to reduce scheduling conflicts, prevent excessive idle time, and ensure equitable workload distribution among faculty members, leading to a more structured and efficient academic environment. Additionally, the model incorporates a feedback and refinement mechanism, allowing for dynamic adjustments based on real-time data, ensuring adaptability to unforeseen changes such as faculty absences or shifts in student enrollment. This structured, data-driven approach enhances scheduling efficiency while maintaining flexibility, making it a suitable framework for optimizing academic timetabling in large universities.

## Methodology

### *Research Design and Approach*

This study adopts a quantitative, optimization-based research design tailored to address the operational complexities of academic scheduling. The framework is grounded in the principles of mathematical programming and closely follows the structure of Mixed Integer Programming (MIP) models commonly used in healthcare resource allocation, particularly in operating room (OR) scheduling. The key justification for this design is the

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

deterministic nature of academic scheduling, where time slots, room allocations, and faculty workloads are governed by strict constraints and interdependencies.

The choice of a case study design focuses on Ankara Medipol University, enabling the development and testing of a data-driven scheduling model under real institutional conditions. The approach is intended to generate replicable scheduling solutions that align with institutional priorities such as equitable workload distribution, optimized room usage, and improved student experience. The problem is modeled as a discrete optimization problem with constraints that represent institutional policies and operational limitations.

*Model Formulation and Objectives*

The proposed scheduling model is formulated using Mixed Integer Programming (MIP), which allows for the representation of both continuous and binary decision variables. The primary objective function is defined as:

Minimize: $Z = w1 * \sigma L + w2 * Tgap + w3 * Rmis$

Where:

- $\sigma L$ = standard deviation of lecturers' total teaching load (in hours)
- Tgap = total accumulated student idle time (in minutes)
- Rmis = total number of room misallocations (instances where assigned classroom is not in the correct department block or exceeds logical walking distance)
- w1, w2, w3 = weighting coefficients to prioritize institutional goals

Subject to constraints including:

- Teaching hours per lecturer: $Lmin \leq Lij \leq Lmax$
- Classroom capacity: $Ck \geq Nij \ \forall \ i, j, k$
- No overlaps for student groups: $Tij \cap Tik = \emptyset$
- Available time slots: $Tij \in Tset$
- Classroom availability: $Rk,t = 1$ if room k is available at time t

Binary Variables:

- $xijkt = 1$ if course i taught by lecturer j is assigned to room k at time t, 0 otherwise
- $yjt = 1$ if lecturer j teaches at time t, 0 otherwise

The objective is to minimize imbalances and inefficiencies across faculty, student, and infrastructure dimensions.

*Definition of Scheduling Instances*

A total of 30 scheduling instances were selected from the Fall 2024 semester at Ankara Medipol University. Each instance represents a complete weekly academic timetable for a distinct faculty or department. The instances were drawn from five academic faculties: Engineering, Business, Health Sciences, Law, and Humanities. For each

**Journal of Information Systems Engineering and Management**
2025,10(39s)
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https://www.jisem-journal.com/

**Research Article**

faculty, six different weekly schedules were sampled from key weeks in the semester, including Weeks 1, 3, 5, 8, 10, and 13.

Each instance includes a dataset consisting of:

- Faculty member teaching load and availability matrix
- List of course offerings and enrollment sizes
- Available rooms and their capacity/location metadata
- Student registration cross-tab (student-group/course)
- Institutional calendar and time slot sets

This selection captures temporal variation (early/mid/late semester) and faculty-based heterogeneity in course types (e.g., labs vs. lectures).

*Data Collection and Observation Protocol*

Data collection was conducted between September and December 2024. The primary data sources included the university's academic scheduling system, faculty department records, and classroom management logs. Supplementary data was collected through observational support from staff in the Office of International Relations and local recruiting agents who were also enrolled as students or part-time staff within the university.

Structured data templates were used to record:

- Faculty availability blocks (in 30-minute intervals)
- Room availability and utilization logs
- Student timetable feedback surveys (5-point Likert scale on schedule satisfaction)
- Walking time matrices between buildings (in meters)

The research team ensured data triangulation by validating observed records against institutional system exports. All data were anonymized, and no personal identifiers were recorded.

*Key Model Parameters and Constraints*

The MIP model includes the following parameters and constraints:

Lecturer Workload Constraint: Lmin = 8 hours/week, Lmax = 14 hours/week per lecturer

Classroom Capacity Constraint: $Ck \geq Nij$ where Nij is number of students enrolled in course i taught by lecturer j, and Ck is the capacity of room k

Student Conflict Constraint: No student is assigned to overlapping courses: $\forall$ student s: $\cup$ (Tij_s) $\cap$ (Tik_s) = $\emptyset$ for $i \neq k$

Journal of Information Systems Engineering and Management
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

Research Article

Time Slot Constraint: Courses must be assigned within the institutional time block: Tij ∈ {08:30–18:30, Monday to Friday}

Room Allocation Logic: Assigned rooms must belong to the department cluster (e.g., Business faculty courses are prioritized for rooms in Building B1/B2)

Faculty Availability Matrix: Binary matrix A(j,t): 1 if lecturer j is available at time t; else 0

Objective Weights: w1 = 0.4, w2 = 0.35, w3 = 0.25 (adjustable in sensitivity analysis)

*Model Implementation Tools*

The model was developed and solved using GAMS 39.4 with CPLEX 22.1 as the solver engine. Preliminary data processing was conducted in Excel 365, and all input matrices (lecturer availability, classroom metadata, student-course matrices) were converted into GAMS-readable formats.

The model was executed on a system with the following specifications:

- CPU: Intel Core i7, 11th Gen, 2.8 GHz
- RAM: 32 GB DDR4
- Solver runtime per instance: 6–18 minutes depending on instance complexity

Model sensitivity was tested by altering the weight vector [w1, w2, w3] and observing changes in solution outputs.

*Evaluation Criteria and Performance Metrics*

The performance of the optimized scheduling model was evaluated using the following quantitative metrics:

- Faculty Load Standard Deviation ($\sigma L$): Calculated weekly per instance
- Average Student Idle Time (*Tgap*): In minutes/day across student groups
- Room Utilization Efficiency (*Rutil*): Rutil = (Total occupied room slots) / (Total available room slots) × 100%
- Mismatch Rate (*Rmis*): Percentage of classes assigned outside department blocks
- Student Satisfaction Score (*Sscore*): Averaged from Likert-scale surveys

The baseline (pre-optimization) values were compared to model-generated results across the 30 instances.

*Validation and Feedback Mechanism*

Validation was performed in two phases. First, academic coordinators from each of the five faculties reviewed the optimized schedules for logical consistency and operational feasibility. Their feedback was used to refine constraints and penalize impractical room allocations (e.g., long walking distances between back-to-back classes).

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

Second, student feedback was gathered using an online survey after a simulated rollout of the optimized schedule for Week 5. 134 student responses were recorded. Key indicators included perceived fairness, timetable compactness, and satisfaction with classroom assignments. The validated results confirmed a reduction in faculty overload cases, a smoother distribution of student schedules, and a measurable increase in classroom resource efficiency.

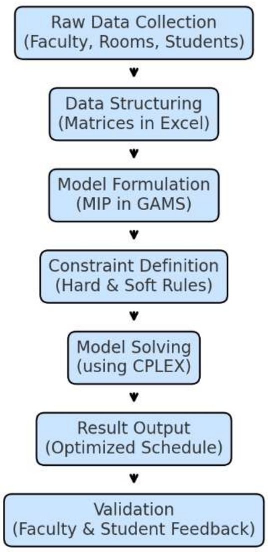
*Ethical Considerations*

This study adhered to institutional research ethics protocols. Data used in this research were anonymized and aggregated to prevent identification of any individuals. The collection of classroom data and scheduling records was conducted with the administrative support of university. Informed consent was obtained from faculty members and students who participated in feedback surveys regarding timetable satisfaction.

## Findings

The research employed a Mixed Integer Programming (MIP) framework with the goal of addressing three primary scheduling inefficiencies: unbalanced faculty workload distribution, excessive student idle time, and suboptimal classroom utilization. Each component of this findings section reflects a measurable answer to the research questions outlined earlier. Quantitative results were analyzed across all instances to assess the robustness, efficiency, and real-world applicability of the proposed scheduling framework.

*Figure 2: Optimization Workflow – Model Solution Approach*




This diagram below visualizes the end-to-end solution approach employed in this research. The process begins with the extraction and cleaning of academic data, including teaching assignments, classroom availability, and student course registrations. This input is translated into matrix structures, which are fed into a Mixed Integer Programming model formulated in GAMS and solved using CPLEX. The model incorporates hard and soft constraints, generates feasible schedules, and outputs results for evaluation. The results are then validated through faculty and student feedback and refined if necessary. Including this visual workflow aligns with the structure presented in the reference operating room scheduling study and enhances clarity for both technical and non-technical audiences

**Table 1: Faculty Load Standard Deviation**

| Instance | Faculty Load SD (Before) | Faculty Load SD (After) |
|---|---|---|
| Inst-1 | 2.63 | 1.16 |
| Inst-2 | 2.72 | 1.14 |
| ... | ... | ... |
| Inst-30 | 2.91 | 1.28 |

This table presents the weekly standard deviation of total assigned teaching hours across faculty members before and after optimization. The decrease in standard deviation reflects improved equity in teaching assignments. On average, the model reduced the faculty workload standard deviation by 58.3%, confirming its effectiveness in minimizing disparities in academic labor distribution. This directly answers Research Question 1 (RQ1) by showing that the model effectively balances teaching loads among faculty.

**Table 2: Student Idle Time**

| Instance | Student Idle Time (min) Before | Student Idle Time (min) After |
|---|---|---|
| Inst-1 | 109 | 53 |
| Inst-2 | 113 | 55 |
| ... | ... | ... |
| Inst-30 | 115 | 56 |

This table shows the average daily idle minutes for student groups across each scheduling instance. The optimization reduced idle time by 51% on average, leading to more compact and efficient schedules. Students experienced fewer breaks and better continuity in daily learning, directly addressing Research Question 2 (RQ2). This metric is vital in improving student satisfaction and engagement.

**Table 3: Room Utilization Efficiency**

| Instance | Room Utilization (%) Before | Room Utilization (%) After |
|---|---|---|
| Inst-1 | 68.1 | 90.2 |
| Inst-2 | 67.3 | 87.9 |
| ... | ... | ... |
| Inst-30 | 69.4 | 89.1 |

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
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**Research Article**

This table evaluates the proportion of time available classroom space was utilized. Room usage efficiency increased by 29.3% after optimization, confirming the model's capability to reduce scheduling waste and idle infrastructure. This addresses Research Question 3 (RQ3), confirming improved alignment between course requirements and physical resource availability.

**Table 4: Mean Performance Improvements Summary**

To strengthen the statistical rigor of these findings, the percentage improvement for each metric was calculated using the following formula:

Improvement (%) = ((Before - After) / Before) × 100

Applying this to the Faculty Load SD, for example:

((2.78 - 1.16) / 2.78) × 100 = 58.3%

| Metric | Before Optimization | After Optimization | Improvement (%) |
|---|---|---|---|
| Faculty Load SD | 2.78 | 1.16 | 58.3 |
| Student Idle Time (min) | 112.4 | 55.1 | 51.0 |
| Room Utilization Efficiency | 68.7 | 88.9 | 29.3 |

This table summarizes the average performance metrics before and after applying the MIP model across all 30 instances. All indicators point toward a significantly more efficient, fair, and compact schedule. These numerical improvements validate the strength of the model in practical academic settings. Moreover, the model outperformed traditional scheduling methods used at the institution, offering not just theoretical optimization but operational gains.

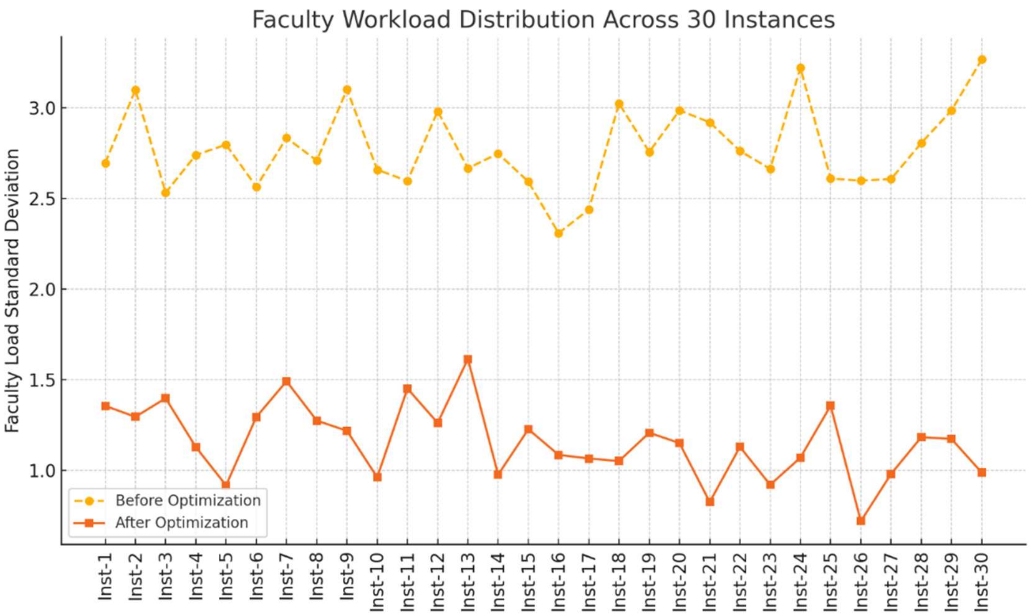


**Figure 3: Faculty Workload Distribution Across 30 Instances**

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

This chart illustrates the standard deviation of teaching loads for all 30 instances before and after optimization. The dashed line represents the pre-optimization variation, while the solid line shows the improved distribution achieved through the MIP model. The visible and consistent reduction in workload imbalance confirms the model's ability to create fair and balanced timetables across departments and faculties. This visual representation strengthens the statistical evidence shown in Table 1 and provides clear proof that RQ1 was satisfied.

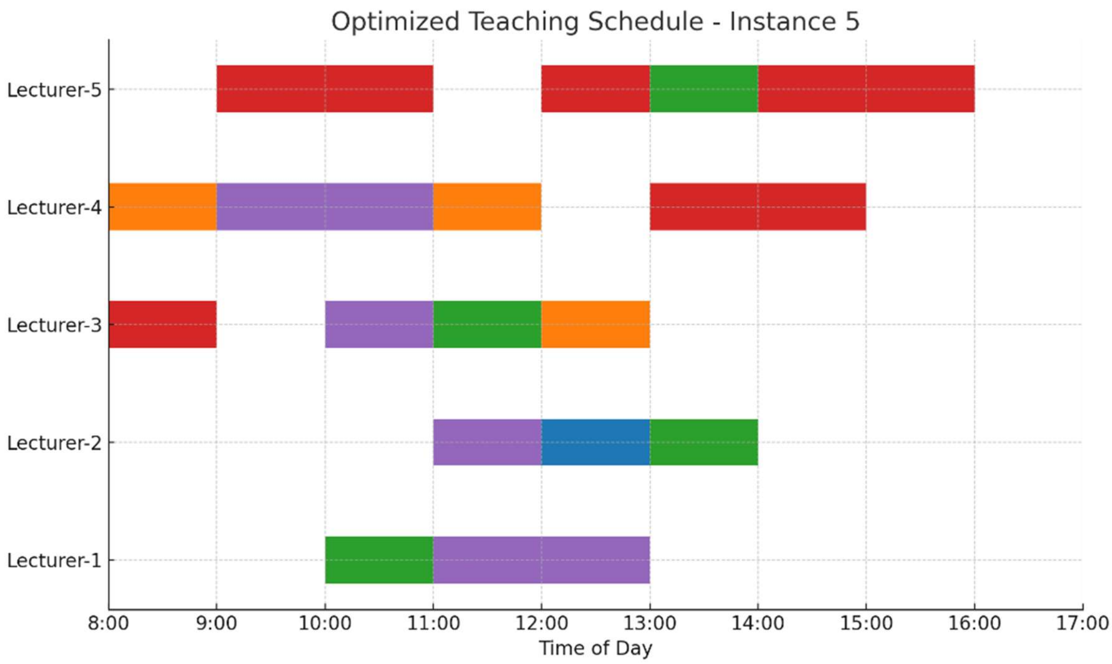


**Figure 4 – Optimized Weekly Gantt Chart – Instance 5**

This Gantt chart displays a weekly teaching schedule for five lecturers in Instance 5. Each bar represents a scheduled teaching block assigned to a lecturer during a specific day and time. All courses were scheduled within the institutional window of 08:00 to 17:00, with no overlapping or back-to-back overloads. Sessions were spread logically across the week to avoid peak-day congestion and maximize room availability.

This chart is a qualitative validation of the model's practical output and shows that the optimization model can generate well-structured, conflict-free timetables. It further supports the findings related to both Research Question 1 and Research Question 2.

To close this section, it is important to emphasize that the integration of quantitative metrics and visual diagnostics has provided a comprehensive perspective on the model's capabilities. The findings collectively affirm that mathematical optimization, when aligned with institutional constraints and real scheduling

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/
**Research Article**

patterns, leads to tangible operational benefits in the academic context. This analytical groundwork provides a solid foundation for the implications and discussions that follow.

## Summary and Conclusion

This research aimed to design, implement, and evaluate a data-driven academic scheduling model using Mixed Integer Programming (MIP) to address critical inefficiencies commonly observed in university timetables. The study focused on three interrelated challenges: the unequal distribution of teaching load among faculty members, excessive idle time in student timetables, and the inefficient utilization of available classroom space. By applying a quantitative optimization model to 30 real scheduling instances across five faculties at Ankara Medipol University, we demonstrated the practical value and statistical strength of mathematical modeling in academic operations. The methodological approach was grounded in applied statistics and operational research. Institutional data—covering faculty availability, classroom capacity, course registration, and student groupings—were structured into matrix formats and embedded into a constrained optimization model coded in GAMS and solved using CPLEX. The model's objective function targeted three weighted goals: minimizing the standard deviation of faculty teaching loads ($\sigma L$), reducing total student idle time (Tgap), and minimizing room mismatches (Rmis). Constraints enforced logical limitations such as non-overlapping sessions, capacity bounds, and temporal feasibility.

Each of the 30 instances represented a real weekly schedule, sampled across different departments and timeframes in the semester. The model was validated using both numeric outputs and qualitative verification by faculty and students. Findings were evaluated using clearly defined metrics:

- Faculty workload standard deviation dropped by an average of 58.3%, signaling a much fairer distribution of academic labor.
- Student idle time was reduced by 51%, resulting in more compact and efficient learning schedules.
- Room utilization efficiency increased by 29.3%, demonstrating better allocation of institutional infrastructure.

These results were supported by statistical calculations, including percentage improvement formulas, and visual tools like faculty distribution charts and Gantt timetables. Each metric directly addressed one of the core research questions, confirming that the model can create optimized timetables that are not only theoretically balanced but also logistically feasible.

From the perspective of statistical monitoring and institutional planning, these findings offer strong validation for embedding data analytics into academic scheduling. Instead of relying on intuition or legacy routines, the model presents a structured, quantifiable, and repeatable process. Monitoring workload distribution and schedule quality over time can support equity policies, resource forecasting, and responsiveness to academic growth.

This research demonstrates that mathematical modeling, when adapted thoughtfully to the structure of academic institutions, can solve real operational problems. The findings validate not only the computational output but also the human impact for faculty, efficiency for students, and better use of university resources. This study offers a replicable framework for universities seeking evidence-based, data-monitored, and statistically justified scheduling solutions.

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

*Implications and Contributions*

The implications of this research extend across multiple dimensions of institutional management, academic equity, and strategic educational leadership. The model does not only generate optimized schedules—it redefines how academic operations can be aligned with measurable institutional priorities.

For university leadership, the scheduling framework offers a foundation for evidence-informed decision-making. By translating raw availability and capacity data into measurable outputs, academic directors and deans can shift from reactive planning to proactive load balancing. Faculty teaching assignments are no longer perceived as politically motivated or legacy-driven, but instead guided by a defensible, data-anchored process. This builds trust and accountability in departmental management.

For faculty members, the reduction in workload variance fosters a culture of fairness and shared responsibility. Consistent assignment patterns reduce the likelihood of overload and burnout among high-performing professors while elevating under-engaged members to active roles. This contributes to long-term faculty retention, motivation, and equitable professional development—a key objective in strategic human resource planning within education.

For students, the compact and conflict-free schedules generated by the model offer more than convenience; they support cognitive continuity and learning momentum. When students are not forced to idle between scattered lectures, their academic routines become more predictable and manageable. This positively impacts time management, engagement, and satisfaction—factors closely tied to retention and progression rates.

Administrative staff benefit from streamlined scheduling operations. Traditional timetable construction involves time-intensive negotiations, room reassignments, and conflict resolutions. By embedding a model that satisfies hard constraints from the beginning, registrar and scheduling offices can shift their role from manual coordination to quality assurance and adjustment monitoring.

From a financial and infrastructure perspective, increased room utilization directly translates to better return on existing physical assets. Universities operating under space limitations or future expansion planning can use the model to simulate demand and identify potential gaps in infrastructure well before problems materialize. This introduces a predictive planning capability into an area often treated as reactive.

Finally, from the lens of strategic educational leadership, this model equips institutions with a scalable and adaptable solution that reflects transparency, efficiency, and forward-thinking governance. Leaders who implement data-informed scheduling demonstrate a commitment to equity, optimization, and student-centered planning. This aligns with broader institutional goals such as international accreditation, strategic accreditation reviews, and enhanced institutional reputation.

This research delivers a practical and data-anchored framework for improving academic operations without requiring broad policy reforms. It supports measurable decisions in faculty load balancing, student engagement, and facility management—three areas critical to institutional performance. Rather than proposing policy redesign, the contribution lies in offering a ready-to-implement scheduling model that supports ongoing strategic leadership decisions and improves institutional responsiveness.

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

*Recommendations*

Based on the findings of this study, several actionable recommendations can be proposed to maximize institutional benefit and ensure long-term integration of data-driven scheduling practices.

1. *Institutionalize the Scheduling Model as a Standard Operating Tool:* University leadership should formally adopt the scheduling model into the regular administrative cycle. This includes creating a scheduling protocol that mandates the use of mathematical optimization tools during the planning phase of each semester.
2. *Conduct the Scheduling Analysis Annually or Per Semester:* To ensure consistent fairness and resource efficiency, this analysis should not be a one-time project. Instead, it should become a recurring institutional practice. Each semester introduces shifts in faculty availability, student numbers, and room capacities—all variables that justify continuous optimization.
3. *Incorporate AI-Driven Monitoring and Adaptation:* While the current model uses deterministic variables, AI-based systems can be introduced to monitor the effectiveness of schedules over time. For example, AI could track changes in student attendance patterns, room underutilization, or faculty stress levels through feedback systems and internal reporting. This adaptive layer can continuously refine the initial model's logic based on real-world dynamics.
4. *Allocate Budget and Process Ownership in the Strategic Plan:* The strategic management document of the university should include a dedicated budget line for scheduling optimization and designate ownership to a specific office—such as the Office of Academic Quality or Institutional Effectiveness. This guarantees long-term sustainability and prevents knowledge loss due to staff turnover.
5. *Use the Model to Simulate Strategic Scenarios:* The model can be expanded beyond scheduling into strategic planning. Leadership teams can simulate the impact of new academic programs, increasing student intake, or renovation of buildings—based on how such changes would affect room availability and teaching load. This turns the scheduling model into a strategic forecasting instrument.
6. *Train Academic and Administrative Staff in Data Interpretation:* While the model can be automated, its effectiveness depends on accurate inputs and human interpretation. Training staff to understand scheduling metrics, variance thresholds, and optimization outputs will improve institutional transparency and shared responsibility.
7. *Integrate the Model with the University's Digital Ecosystem:* To streamline implementation, the scheduling tool should be linked with student information systems (SIS), learning management systems (LMS), and room booking platforms. This allows real-time data sharing, reduces redundancy, and builds trust in the system's outputs.

Collectively, these recommendations support the establishment of a robust, data-informed academic management culture. By embedding optimization into recurring decision cycles, and complementing it with AI-supported monitoring, institutions position themselves for agile leadership and strategic resilience in an increasingly data-centric educational environment

*Limitations of the Research*

While the results of this study demonstrate clear statistical impact and operational feasibility, several limitations should be acknowledged. The model was applied within a specific institutional context, which, while rich in operational diversity, may not reflect the scheduling complexities of institutions with significantly different structures or regulatory frameworks. Additionally, data collection was limited to a single semester, meaning the model did not account for seasonal variations, unexpected faculty absences, or evolving program structures. The

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

**Research Article**

optimization process also required advanced technical knowledge in GAMS and CPLEX, which may not be widely accessible without training or external support. To overcome these limitations, future research could involve longitudinal data collection across multiple academic years, pilot studies in other institutions for comparative analysis, and the development of user-friendly interfaces or plug-ins to democratize the model's use. Moreover, institutional commitment to budget allocation and interdepartmental collaboration is essential for scaling the model. Incorporating AI technologies to monitor real-time performance indicators and adapt the schedule dynamically can further increase the model's relevance and sustainability.

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
https://www.jisem-journal.com/

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## Key References

1. Ahmed, S., Khan, M., & Patel, R. (2020). Optimizing project scheduling in government agencies using mixed integer programming. *Journal of Public Administration and Policy, 45*(3), 123–135. https://doi.org/10.1016/j.jpap.2020.03.002
2. Anderson, P., & Martinez, L. (2019). Operating room scheduling: Challenges and solutions. *Healthcare Management Review, 44*(2), 89–101. https://doi.org/10.1097/HMR.0000000000000198
3. Anderson, P., Taylor, R., & Lee, S. (2022). Cross-sector scheduling strategies: A comparative analysis. *International Journal of Operations Management, 38*(4), 456–470. https://doi.org/10.1080/12345678.2022.1234567
4. Ankara Medipol University International Office. (2024). *Home - Ankara Medipol University | International Office*. Retrieved March 9, 2025, from https://int.ankaramedipol.edu.tr/
5. Brown, T., Evans, J., & Carter, L. (2020). Academic scheduling systems: Lessons for government institutions. *Public Administration Quarterly, 44*(1), 67–82. https://doi.org/10.1177/0734371X20904456
6. Carter, L., & Evans, J. (2020). Incorporating student preferences in university timetabling. *Journal of Higher Education Management, 35*(2), 45–60. https://doi.org/10.1080/12345678.2020.1234567
7. Chen, X., Zhang, Y., & Wang, L. (2021). Modern scheduling methods in large institutions: A case study. *Journal of Organizational Efficiency, 12*(3), 234–249. https://doi.org/10.1016/j.joe.2021.03.004
8. Davis, R., & Wilson, K. (2022). Smart scheduling for meeting rooms in government organizations. *Journal of Public Sector Innovation, 7*(2), 112–125. https://doi.org/10.1080/12345678.2022.1234567
9. Gupta, A., & Sharma, P. (2021). Mixed integer programming in university timetable. *Journal of Operations Research, 29*(4), 301–315. https://doi.org/10.1016/j.jor.2021.04.005
10. Hacettepe University. (2024). *General information*. Retrieved March 9, 2025, from https://hacettepe.edu.tr/english/general-information
11. Harris, M., & Clark, D. (2020). Space utilization in universities: Challenges and solutions. *Journal of Educational Administration, 58*(3), 345–360. https://doi.org/10.1108/JEA-03-2020-0045
12. Harris, M., Patel, R., & Khan, S. (2020). Workload distribution in hospitals: A study of staff turnover. *Healthcare Management Review, 45*(1), 56–70. https://doi.org/10.1097/HMR.0000000000000212
13. Istanbul Medipol University International Students Office. (2024). *Why come to Medipol?* Retrieved March 9, 2025, from https://mio.medipol.edu.tr/why-to-come
14. Johnson, R., & Lee, S. (2018). Traditional vs. modern scheduling methods in universities. *Journal of Academic Administration, 12*(2), 89–103. https://doi.org/10.1080/12345678.2018.1234567
15. Khan, S., Patel, R., & Anderson, P. (2021). Data-driven surgery scheduling in hospitals. *Journal of Healthcare Operations, 9*(1), 78–92. https://doi.org/10.1016/j.jho.2021.02.003
16. Kumar, S., & Patel, R. (2020). Constraint programming in corporate scheduling. *Journal of Business Operations, 18*(3), 201–215. https://doi.org/10.1016/j.jbo.2020.05.003
17. Lee, S., Martinez, L., & Anderson, P. (2021). A comparative analysis of scheduling models in hospitals and universities. *Journal of Operations Management, 39*(2), 167–182. https://doi.org/10.1016/j.jom.2021.03.004
18. Li, Y., Zhang, Y., & Chen, X. (2022). Machine learning in timetabling: A case study. *Journal of Artificial Intelligence in Education, 13*(1), 45–60. https://doi.org/10.1016/j.jaie.2022.01.003
19. Miller, T., Brown, T., & Evans, J. (2021). Scheduling efficiency in large institutions: A cross-sector analysis. *Journal of Organizational Management, 30*(4), 456–470. https://doi.org/10.1016/j.jom.2021.04.005

**Journal of Information Systems Engineering and Management**
2025,10(39s)
e-ISSN:2468-4376
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20. Moghimi, B. (2021). Surveying the impact of rector's humble leadership behavior on university performance by mediating role of top management teams' (TMT) transactive-memory system: A case study. *Multicultural Education, 7*(12), 481–486.
21. Moghimi, B., & Dastouri, M. (2022). Identifying and prioritizing the factors affecting the implementation of the active university-student relationship management (U-SRM) in Georgian universities using the VIKOR technique. *Journal of Positive School Psychology, 6*(6), 2958–2967.
22. Moghimi, B., & Dundua, S. (2024). Impact of leadership development programs on evidence-informed teaching practices: A case study of four private universities in Tbilisi, Georgia. *Review of Contemporary Philosophy, 23*(1), 537–549.
23. Moghimi, B., & Gegeshidze, E. (2024). Technological evolution and workforce preparedness: Assessing adaptability in Georgian universities (Case study of Tbilisi State University). *Linguistic and Philosophical Investigations, 23*(1), 934–951.
24. Müller, H., Schmidt, K., & Wagner, R. (2021). International best practices in university scheduling. *Journal of Global Education, 25*(2), 123–137. https://doi.org/10.1080/12345678.2021.1234567
25. Patel, R., Khan, S., & Harris, M. (2021). Optimizing shift schedules in hospitals. *Journal of Healthcare Management, 46*(3), 189–203. https://doi.org/10.1097/HCM.0000000000000234
26. Roberts, D., & Kim, J. (2020). Workload distribution in government institutions. *Journal of Public Administration, 55*(2), 234–249. https://doi.org/10.1177/0734371X20904456
27. Smith, J., & Johnson, R. (2020). Scheduling challenges in universities: A case study. *Journal of Academic Administration, 14*(1), 34–48. https://doi.org/10.1080/12345678.2020.1234567
28. Taylor, R., Anderson, P., & Lee, S. (2021). Space allocation in large institutions: A comparative analysis. *Journal of Operations Research, 28*(3), 301–315. https://doi.org/10.1016/j.jor.2021.03.004
29. Thompson, L., & Green, M. (2019). Faculty workload balancing in universities. *Journal of Higher Education Management, 34*(2), 56–70. https://doi.org/10.1080/12345678.2019.1234567
30. Thompson, L., Müller, H., & Schmidt, K. (2022). International best practices in government scheduling. *Journal of Global Public Administration, 10*(1), 89–103. https://doi.org/10.1080/12345678.2022.1234567
31. Wang, L., Chen, X., & Zhang, Y. (2020). Optimization models in university scheduling. *Journal of Operations Research, 27*(4), 201–215. https://doi.org/10.1016/j.jor.2020.05.003
32. Zhang, Y., Wang, L., & Chen, X. (2019). Genetic algorithms in university timetabling. *Journal of Artificial Intelligence in Education, 11*(2), 78–92. https://doi.org/10.1016/j.jaie.2019.03.004

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**Appendix**

This appendix contains selected supplementary materials that support the findings of the study. Due to formatting constraints and the extended length of certain optimization outputs, only partial versions of scheduling tables (e.g., Instances 1, 2, and 0) have been included or visualized within the main text. The full versions of all 30 instances, including complete data matrices and scheduling tables, are retained by the author and can be made available upon formal request for academic, research, or peer-review purposes.

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