AI-Based Smart Staff Scheduling and Class Reminder Notification System A Comprehensive Survey

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Abstract: Timetable scheduling in educational institu-tions is a complex and critical task that involves allocating subjects, teachers, classrooms, and time slots while satisfy-ing multiple constraints. Traditional manual methods often lead to conflicts such as overlapping classes, improper class-room allocation, and uneven workload distribution among faculty members. Over the years, several approaches have been proposed to solve this problem, including optimiza-tion techniques, constraint-based scheduling, genetic algo-rithms, and artificial intelligence-based systems. This paper presents a comprehensive literature sur-vey of existing methods used for solving the university course timetabling problem. Various techniques such as Mixed Integer Linear Programming (MILP), optimization models, graph coloring, particle swarm optimization, and hybrid metaheuristic approaches are analyzed in detail. Each method is evaluated based on efficiency, scalability, flexibility, and ability to handle real-time changes. The analysis reveals that while optimization-based ap-proaches provide highly accurate and conflict-free sched-ules, they lack adaptability to dynamic environments.On the other hand, AI-based techniques offer flexibility but require higher computational resources. Most of the exist-ing systems also fail to provide features such as real-time updates, automatic teacher substitution, and intelligent notification systems. To overcome these limitations, a smart staff schedul-ing and timetable management system is proposed. The proposed system integrates artificial intelligence with opti-mization techniques to generate efficient timetables, detect conflicts, allocate classrooms dynamically, and provide real-time notifications to users. This approach aims to improve scheduling efficiency, reduce manual effort, and enhance the overall academic management process.

Keywords: *Artificial Intelligence, Staff Scheduling, University Course Timetabling, Genetic Algorithm, Ex-Plainable Artificial Intelligence, Educational Analytics, Recommendation System, Smart Campus, Academic Man-Agement.*

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I. INTRODUCTION

The rapid advancement of Artificial Intelligence (AI), optimization techniques, and intelligent decision-support systems has significantly transformed academic manage-ment in higher educational institutions. Among various administrative activities, university course timetabling and staff scheduling remain challenging because they require the simultaneous allocation of teachers, class-rooms, subjects, and time slots while satisfying nu-merous hard and soft constraints. Traditional manual scheduling methods are time-consuming, error-prone, difficult to modify, and often fail to generate conflict-free timetables in large educational institutions [1]–[3]. To overcome these challenges, researchers have pro-posed numerous optimization techniques for solving the University Course Timetabling Problem (UCTP). Several survey studies have reviewed the application of Genetic Algorithms, Simulated Annealing, Constraint Program-ming, Integer Programming, Particle Swarm Optimiza-tion, Ant Colony Optimization, Hyper-heuristics, and Hybrid Metaheuristic approaches for generating efficient academic timetables while minimizing scheduling con-flicts and improving resource utilization [1]–[6]. Math-ematical optimization models such as Mixed Integer Linear Programming (MILP) have also been applied to synchronize coursework schedules, balance faculty workload, and optimize timetable quality under multiple institutional constraints [7].

Recent developments in Artificial Intelligence and Machine Learning have further improved academic scheduling by enabling intelligent timetable generation, adaptive optimization, and automated decision support. Evolutionary optimization methods, particularly Genetic

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Algorithms, have demonstrated excellent performance in producing high-quality schedules while satisfying institutional constraints and user preferences [5], [6], [8]. In addition, AI-assisted scheduling frameworks and intel-ligent timetable generation systems have been explored to reduce manual intervention and improve scheduling efficiency in educational institutions [9], [12]–[15].

Besides timetable generation, modern educational institutions increasingly require intelligent recommen-dation systems capable of supporting administra-tive decision-making. Machine Learning-based recom-mended systems, Knowledge-Based Recommendation Systems, and Explainable Artificial Intelligence (XAI) have shown significant potential in improving recom-mendation accuracy, decision transparency, and user trust [16]–[18]. Furthermore, educational analytics dash-boards have become essential tools for monitoring in-stitutional performance, visualizing academic informa-tion, and supporting evidence-based academic decision-making [19].

Although considerable progress has been achieved in timetable optimization, Artificial Intelligence, rec-ommendation systems, and educational analytics, most existing studies address these components independently. Current systems primarily focus on timetable genera-tion or optimization algorithms while providing limited support for intelligent teacher recommendation, dynamic teacher substitution, leave management, Explainable AI, cloud-based synchronization, Android mobile applica-tions, and real-time class reminder notifications [1]–[15], [16]–[18], [19]. Therefore, there is a growing need for an integrated academic management platform capable of combining these technologies into a single intelligent system.

This literature survey presents a comprehensive re-view of recent research related to university course timetabling, optimization algorithms, Artificial Intel-ligence, recommendation systems, Explainable Artifi-cial Intelligence, and educational analytics. The re-viewed studies are systematically analyzed based on their methodologies, algorithms, datasets, advantages, limitations, and research gaps. Based on this analysis, the survey highlights the necessity of developing an AI-Based Smart Staff Scheduling and Class Reminder Notification System that integrates Genetic Algorithm-based optimization, intelligent teacher recommendation, Explainable AI, cloud technologies, and real-time noti-fication services to improve scheduling efficiency, trans-parency, and academic administration.

Timetable generation is an essential activity in aca-demic institutions such as schools,colleges, and univer-sities. It involves assigning subjects to specific time slots, allocating teachers, and ensuring proper utilization of classrooms. The problem becomes more complex when multiple constraints such as teacher availability, subject requirements, and classroom capacity must be satisfied simultaneously. Traditionally, timetable preparation is done manually, which is time-consuming and prone to human errors. As the number of students and courses increases, manual scheduling becomes inefficient and difficult to manage.

➢ *Importance of the Topic*

An efficient timetable system plays a vital role in improving the academic environment. It ensures that there are no clashes between classes, optimizes the use of resources, and maintains a balanced workload for teach-ers. With the advancement of technology, automated timetable systems have gained importance as they reduce manual effort and improve scheduling accuracy. A smart scheduling system can also provide additional features such as real-time updates and notifications, which are highly beneficial in modern institutions.

➢ *Objective of the Study*

The main objective of this study is to analyze various existing timetable generation techniques and identify their strengths and limitations. Based on this analysis, a smart staff scheduling and timetable management system is proposed that can overcome the drawbacks of existing methods and provide an efficient, flexible, and scalable solution.

II. BACKGROUND OF THE DOMAIN

Academic staff scheduling is one of the most im-portant administrative activities in educational institu-tions, as it directly influences teaching quality, faculty workload distribution, classroom utilization, and overall institutional efficiency. The primary objective of staff scheduling is to allocate teachers, classrooms, subjects, and time slots while satisfying institutional policies and minimizing scheduling conflicts. Unlike traditional manual scheduling, modern academic scheduling sys-tems employ Artificial Intelligence (AI), optimization algorithms, and cloud-based technologies to generate efficient and conflict-free timetables [1]–[4].

Developing an intelligent staff scheduling system re-quires understanding the major technologies that con-tribute to automated timetable generation, optimization, recommendation, and decision support. This section briefly discusses the key technologies identified in the reviewed literature and their role in modern academic scheduling systems.

➢ *University Course Timetabling and Staff Scheduling*

The University Course Timetabling Problem (UCTP) is one of the most extensively studied combinatorial op-timization problems because it involves assigning teach-ers, classrooms, subjects, and time slots while satisfying numerous hard and soft constraints. Hard constraints include avoiding faculty clashes, classroom conflicts, and overlapping classes, whereas soft constraints focus on faculty preferences, workload balancing, and preferred teaching schedules. Various optimization approaches have been proposed to improve timetable quality and reduce scheduling conflicts, including Constraint Pro-gramming, Integer Programming, Hyper-Heuristics, and Hybrid Metaheuristic techniques [1]–[7].

➢ *Genetic Algorithm-Based Scheduling*

Among various optimization methods, the Genetic Algorithm (GA) has become one of the most widely adopted techniques for academic staff scheduling be-cause of its

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ability to efficiently search large solution spaces and generate high-quality timetables. Genetic Algorithms simulate natural evolutionary processes us-ing chromosome representation, population initialization, fitness evaluation, crossover, and mutation operations. Several studies have demonstrated that GA effectively satisfies both hard and soft scheduling constraints while improving faculty workload balancing and classroom utilization [5]–[8].

➢ *Artificial Intelligence and Recommendation Systems*

Recent advancements in Artificial Intelligence have enabled educational institutions to move beyond static timetable generation toward intelligent decision-support systems. Machine Learning and Knowledge-Based Rec-ommendation Systems assist administrators by recom-mending suitable faculty members based on subject expertise, teaching experience, workload, and institu-tional policies. These intelligent recommendation tech-niques improve scheduling quality while reducing man-ual decision-making efforts [16], [17].

➢ *Explainable Artificial Intelligence (XAI)*

As Artificial Intelligence becomes increasingly in-volved in academic decision-making, transparency has become an important requirement. Explainable Artificial Intelligence (XAI) enables administrators to understand why a particular scheduling decision has been made, thereby improving user trust and system reliability. XAI techniques provide interpretable explanations for teacher allocation, classroom assignment, and timetable opti-mization decisions, making AI-driven scheduling sys-tems more transparent and accountable [18].

➢ *Educational Analytics and Smart Academic Manage-ment*

Educational analytics has emerged as an essen-tial component of modern academic management sys-tems. By analyzing institutional data, faculty workload, scheduling statistics, and academic performance, educa-tional analytics supports informed decision-making and continuous institutional improvement. Interactive dash-boards and learning analytics platforms provide adminis-trators with meaningful insights into academic operations and resource utilization [19].

➢ *Research Motivation*

Although considerable progress has been achieved in timetable optimization, Artificial Intelligence, rec-ommendation systems, and educational analytics, ex-isting studies mainly focus on individual components rather than providing a unified academic management solution. Most available systems lack intelligent teacher recommendation, dynamic teacher substitution, Explain-able AI, cloud-based synchronization, Android mobile applications, and real-time class reminder notifications within a single platform [1]–[15], [16]–[18], [19]. This limitation motivates the development of an integrated AI-Based Smart Staff Scheduling and Class Reminder Notification System capable of automating academic scheduling while improving transparency, adaptability, and administrative efficiency.

III. LITERATURE SURVEY

This section reviews nineteen selected research papers related to AI-based staff scheduling, university course timetabling, optimization algorithms, intelligent recom-mendation systems, Explainable Artificial Intelligence (XAI), and educational analytics. The reviewed stud-ies are organized into thematic categories, including survey papers on university timetabling, optimization-based scheduling systems, Artificial Intelligence-based recommendation systems, Explainable AI techniques, and educational analytics for academic management.

➢ *University Course Timetabling and Staff Scheduling*

- *A Survey of University Course Timetabling Prob-Lem: Perspectives, Trends and Opportunities [1]:*

This survey provides a comprehensive review of the Uni-versity Course Timetabling Problem (UCTP) by an-alyzing various optimization approaches, benchmark datasets, and research trends. The study compares Ge-netic Algorithms, Simulated Annealing, Tabu Search, Particle Swarm Optimization, Ant Colony Optimiza-tion, Constraint Programming, Integer Programming, Hyper-Heuristics, and Hybrid Metaheuristic techniques for solving academic scheduling problems. The authors conclude that although significant improvements have been achieved in timetable optimization, most existing approaches focus primarily on static timetable generation and provide limited support for real-time scheduling, teacher substitution, Explainable AI, and cloud-based academic management. This paper establishes the theo-retical foundation for our proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

- *Meta-Heuristic Approaches for the University Course Timetabling Problem [2]:*

This paper reviews modern metaheuristic techniques used for university course timetabling, including Genetic Algorithms, Par-ticle Swarm Optimization, Simulated Annealing, Ant Colony Optimization, Harmony Search, Variable Neigh-borhood Search, and Hybrid Metaheuristics. The study compares the strengths and limitations of these optimiza-tion methods while identifying future research trends. The authors emphasize that existing optimization algo-rithms require greater adaptability to support dynamic scheduling environments and real-time timetable modi-fications. This paper provides guidance for selecting effi-cient optimization techniques in our proposed scheduling framework.

- *A Survey of Approaches for University Course Timetabling Problem [3]:*

This survey classifies exist-ing university course timetabling approaches into In-teger Programming, Constraint Programming, Genetic Algorithms, Simulated Annealing, Tabu Search, Particle Swarm Optimization, Ant Colony Optimization, and Multi-Agent Systems. The paper highlights benchmark datasets and scheduling constraints commonly used in academic institutions. Although the survey provides a comprehensive review of optimization techniques,

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it does not consider Artificial Intelligence, mobile applications, or intelligent decision-support systems. This paper pro-vides the theoretical background for selecting suitable optimization algorithms in our proposed system.

- *Educational Timetabling: Problems, Benchmarks, and State-of-the-Art Results [4]:*

This paper presents a detailed review of educational timetabling formu-lations, benchmark datasets, and state-of-the-art opti-mization techniques. It summarizes the performance of Genetic Algorithms, Constraint Programming, Hyper-Heuristics, Local Search, and Hybrid Optimization ap-proaches while emphasizing reproducibility and stan-dardized benchmarking. However, the study focuses mainly on algorithm evaluation and provides limited discussion on intelligent academic management systems. This paper supports the evaluation methodology adopted in our literature survey.

- *A Survey of Genetic Algorithms for the University Timetabling Problem [5]:*

This survey focuses exclu-sively on Genetic Algorithms for university timetabling by reviewing chromosome representation, fitness func-tions, crossover operators, mutation strategies, and adap-tive Genetic Algorithm variants. The study demonstrates that Genetic Algorithms effectively satisfy both hard and soft scheduling constraints while producing high-quality timetables. However, it does not consider recent Artificial Intelligence techniques such as Explainable AI, recommendation systems, or smart campus technologies. This paper provides the optimization foundation for our proposed scheduling engine.

- *A Review of Optimization Algorithms for Uni-Versity Timetable Scheduling [6]:*

This review com-pares several optimization algorithms, including Genetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization, Simulated Annealing, Tabu Search, Artifi-cial Bee Colony, and Hybrid Optimization techniques. The study discusses their strengths, weaknesses, and applicability to university timetable scheduling. The authors highlight the need for optimization techniques capable of supporting increasingly dynamic academic environments. This paper assists in selecting suitable optimization strategies for automated staff scheduling.

➢ *Optimization-Based Staff Scheduling Systems*

- *The University Coursework Timetabling Problem: An Optimization Approach to Synchronizing Course Cal-Endars [7]:*

Mallari et al. proposed a Multi-Objective Mixed Integer Linear Programming (MILP) model for synchronizing university coursework schedules while simultaneously considering instructor workload, student workload, curriculum structure, and institutional con-straints. The proposed optimization model generates high-quality schedules by minimizing timetable conflicts and balancing academic resources. Although the model achieves optimal scheduling performance, its computa-tional complexity increases significantly for large univer-sities with dynamic scheduling requirements. The study also does not consider AI-based decision support, teacher substitution, or mobile notification mechanisms. This paper provides a mathematical optimization foundation for workload balancing and resource allocation in our proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

- *Personal Course Timetabling for University Stu-Dents Based on Genetic Algorithm [8]:*

This paper presents a personalized university timetable generation system based on a Micro Genetic Algorithm. The pro-posed approach optimizes student course schedules by considering personal preferences, subject selection, and timetable conflicts. The evolutionary optimization pro-cess enables faster convergence while generating high-quality personalized schedules. However, the system fo-cuses only on student timetable generation and does not support faculty scheduling, teacher substitution, work-load balancing, or institutional-level academic manage-ment. The Genetic Algorithm framework presented in this paper can be extended to support intelligent staff scheduling in the proposed system.

- *A Survey of Approaches for Designing Course Timetable Scheduling Systems in Tertiary Institutions[9]:*

This survey reviews various timetable scheduling frameworks adopted in higher educational institutions by analyzing rule-based scheduling, constraint satisfaction techniques, Genetic Algorithms, Artificial Intelligence, optimization algorithms, and hybrid scheduling methods. The study discusses the evolution of academic schedul-ing systems and highlights the increasing role of intelli-gent automation in institutional management. However, it primarily focuses on scheduling methodologies and provides limited discussion on Explainable AI, cloud computing, mobile applications, and real-time academic notifications. This paper supports the architectural design of our proposed intelligent scheduling framework.

- *Timetabling Problems and the Effort To-ward Generic Algorithms: A Comprehensive Survey [10]:*

This survey investigates generic optimization frameworks capable of solving multiple educational timetabling problems using Hyper-Heuristics, Genetic Algorithms, Constraint Programming, Simulated An-nealing, and Hybrid Metaheuristics. The study empha-sizes reusable optimization strategies that can be applied across different academic scheduling environments. Al-though generic scheduling frameworks improve adapt-ability, the survey identifies the need for AI-enabled scheduling systems capable of handling dynamic in-stitutional requirements. This paper provides guidance for developing a flexible scheduling engine suitable for various educational environments.

- *A Review of Optimization Algorithms for Univer-sity Timetable Scheduling [11]:*

This review compares several optimization techniques, including Genetic Algo-rithms, Particle Swarm Optimization, Ant Colony Opti-mization, Simulated Annealing, Tabu

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Search, and Hybrid Optimization algorithms for solving university timetable scheduling problems. The authors analyze the strengths and weaknesses of each optimization method while high-lighting the importance of selecting suitable algorithms according to institutional requirements. However, the study mainly focuses on optimization performance and does not address intelligent teacher recommendation, mobile applications, or Explainable AI. This paper fur-ther supports the selection of Genetic Algorithms as the optimization engine in our proposed scheduling system.

- *Smart Timetable System Using AI and ML [12]:*

This study presents an Artificial Intelligence and Ma-chine Learning-based timetable generation framework for educational institutions. The proposed system auto-mates timetable preparation using intelligent scheduling techniques while reducing manual effort and scheduling conflicts. Although the paper demonstrates the feasibility of AI-assisted timetable generation, it provides limited experimental evaluation and is not published in a widely indexed journal. Nevertheless, the conceptual framework supports the integration of AI techniques into automated staff scheduling and academic management.

- *Automated Timetabling System for University Course [13]:*

This conference paper presents an au-tomated university course timetabling system using constraint-based scheduling and optimization techniques. The proposed system considers faculty availability, class-room allocation, and scheduling constraints to generate conflict-free academic timetables. The experimental re-sults demonstrate improved scheduling efficiency com-pared to manual timetable preparation. However, the sys-tem does not incorporate intelligent teacher recommen-dation, dynamic substitute allocation, or real-time notifi-cation mechanisms. This paper supports the automation component of our proposed academic scheduling system.

- *Incorporating Machine Learning to Evaluate Solu-tions to the University Course Timetabling Problem [14]:*

This research introduces a Machine Learning-based sur-rogate evaluation model for predicting timetable quality during the optimization process. Instead of generating timetables directly, the proposed approach estimates timetable quality, thereby reducing optimization time and improving scheduling efficiency. The study demonstrates the potential of Machine Learning to assist optimization algorithms; however, it remains a preprint and requires validation using real institutional datasets. The concepts presented in this paper provide useful insights for en-hancing AI-assisted scheduling decisions in our proposed system.

- *High-Precision, Fair University Course Scheduling During a Pandemic [15]:*

This paper proposes a fairness-oriented scheduling framework based on Integer Linear Programming to optimize university course scheduling under pandemic-related constraints. The model considers classroom capacity limitations, fairness among faculty members, and health-related restrictions while gener-ating conflict-free timetables. Although the approach performs effectively under constrained environments, it is designed specifically for pandemic scenarios and is available only as a preprint. Nevertheless, its fairness-based optimization strategy provides valuable insights for workload balancing in intelligent staff scheduling systems.

Table 1 Comparative Analysis of Previous Studies

Ref.	Research Focus	Algorithm / Technique	Real-Time Support	Storage / Database	Output	Accuracy / Performance
[1]	UCTP Survey	Survey of GA, PSO, SA, TS, ACO	×	Benchmark Datasets	Literature Survey	NR
[2]	Metaheuristic Timetabling	GA, PSO, ACO, Hybrid Methods	×	ITC2002, ITC2007	Optimized Timetable	NR
[3]	Timetabling Survey	CP, GA, SA, TS	×	Benchmark Datasets	Survey Analysis	NR
[4]	Educational Timetabling	Hybrid Optimization	×	Educational Benchmark Datasets	State-of-the-Art Compari-son	NR
[5]	GA Survey	Genetic Algorithms	×	Timetabling Benchmark Data	Optimized Timetable	NR
[6]	Optimization Review	GA, PSO, ACO, SA	×	University Timetable Data	Comparative Review	NR
[7]	Coursework Scheduling	MILP	Limited	Institutional Scheduling Data	Optimized Coursework Schedule	Optimal Solution Reported
[8]	Student Timetabling	Micro Genetic Algorithm	×	Student Course Records	Personalized Timetable	High Scheduling Efficiency
[9]	Scheduling	AI, Rule-Based	×	Institutional Data	Intelligent	NR

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	Survey	Scheduling			Scheduling Framework	
[10]	Generic Timetabling	Hyper-Heuristics	×	Benchmark Datasets	Generic Scheduling Framework	NR
[11]	Smart Timetable	AI & ML	Partial	Institutional Timetable Records	AI-Based Timetable	NR
[12]	Automated Timetable	Constraint Scheduling	Partial	Faculty & Classroom Records	Automated Timetable	Reduced Scheduling Con-flicts
[13]	ML Timetable Evaluation	Machine Learning	×	ITC Benchmark Dataset	Timetable Quality Predic-tion	Improved Evaluation Speed
[14]	Fair Scheduling	Integer Linear Programming	Partial	University Scheduling Data	Fair Timetable Allocation	NR
[15]	Educational Recommen-dation	Random Forest, Decision Tree	✓	Student Academic Database	Personalized Recommen-dation	High Prediction Accuracy
[16]	Knowledge-Based Recommendation	Knowledge Graph, CBR	✓	Knowledge Base / Ontol-ogy	Intelligent Recommenda-tion	NR
[17]	Explainable AI	SHAP, LIME	✓	AI Model Outputs	Explainable Decision Support	NR
[18]	Learning Analytics Dash-board	Educational Analytics	✓	LMS / Academic Database	Analytics Dashboard	NR
[19]	Cloud-Based Learning Platform	Cloud Computing	✓	Cloud Database / Institu- tional Data	Cloud-Based Timetable & Learning Management	NR

Table 1 presents a comparative analysis of the reviewed studies by comparing their research focus, algorithms, real-time support, datasets, outputs, and overall perfor-mance. It can be observed that most of the existing studies primarily focus on solving the University Course Timetabling Problem using optimization techniques such as Genetic Algorithms, Constraint Programming, Mixed Integer Linear Programming, and Hybrid Metaheuristics. While these approaches significantly improve timetable quality and reduce scheduling conflicts, only a few stud-ies provide support for real-time scheduling or dynamic timetable updates. Furthermore, most studies rely on benchmark datasets rather than real institutional cloud-based databases. The comparison also indicates that recommendation systems, Explainable AI, and educa-tional analytics have been investigated separately, high-lighting the need for an integrated AI-based academic management platform capable of combining scheduling, recommendation, cloud synchronization, and real-time notification services.

➢ *Artificial Intelligence-Based Recommendation Sys-Tems*

- *A Machine Learning-Based Recommended System for Improving Students' Learning Experiences [16]:*

This paper presents a Machine Learning-based recom-mended system that analyzes students academic records, learning history, and assessment results to generate per-sonalized recommendations. The proposed framework employs Random Forest and Decision Tree algorithms to improve recommendation accuracy and support aca-demic decision-making. Experimental results demon-strate that machine learning techniques can effectively assist educational institutions in providing personalized recommendations based on historical academic data. However, the proposed recommendation system focuses primarily on students and does not address administrative tasks such as teacher allocation, substitute teacher rec-ommendation, or staff scheduling. This paper is included in our survey because the recommendation framework can be adapted to recommend suitable faculty mem-bers based on subject expertise, teaching experience, workload, and availability in the proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

- *Knowledge-Based Recommended Systems: Overview and Research Directions [17]:*

This survey reviews Knowledge-Based Recommended Systems that utilize domain knowledge, constraint-based reasoning, case-based reasoning, and knowledge graphs to generate intelligent recommendations without relying entirely on historical user interactions. The study discusses various recommendation models capable of addressing the cold-start problem while improving recommendation transparency and decision quality. Although the survey

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focuses on general recommendation systems, it highlights the potential of knowledge-based approaches for supporting complex decision-making environments. However, the study does not specifically consider educational staff scheduling or institutional resource allocation. This paper provides the conceptual foundation for developing an intelligent teacher recommendation engine capable of selecting appropriate substitute teachers based on institutional rules, subject specialization, and faculty qualifications.

➢ *Explainable Artificial Intelligence*

- *Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges Towards Responsible AI [18]:*

This paper presents a comprehen-sive survey of Explainable Artificial Intelligence (XAI) by reviewing various explanation techniques, including SHAPE, LIME, post-hoc interpretation methods, and model-specific explanation frameworks. The authors em-phasize that transparency and understandability are es-sential for increasing user trust in Artificial Intelligence-based decision-support systems. The survey also dis-cusses the challenges associated with balancing model accuracy and explainability in real-world applications. Although the study focuses on general AI systems, it highlights the importance of providing understandable explanations for automated decisions. This paper forms the theoretical basis for incorporating Explainable AI into the proposed scheduling system, enabling adminis-trators to understand why specific teachers, classrooms, and time slots are selected by the AI engine.

➢ *Educational Analytics and Decision Support Systems*

- *Review of Research on Student-Facing Learning Analytics Dashboards and Educational Recommended Systems [19]:*

This review examines the development of educational analytics dashboards and recommended systems that support academic decision-making through visualization of educational data and learning analytics. The study discusses various dashboard architectures, educational data mining techniques, and visualization methods that assist institutions in monitoring academic performance and student engagement. Although the sur-vey mainly focuses on student-centered learning analyt-ics, it demonstrates the importance of interactive dash-boards for presenting meaningful institutional informa-tion. The study provides valuable insights for designing an administrative dashboard capable of monitoring staff workload, timetable statistics, teacher substitution, leave requests, classroom utilization, and notification history within the proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

IV. COMPARATIVE ANALYSIS

The reviewed literature demonstrates that signifi-cant research has been conducted on university course timetabling, optimization algorithms, Artificial Intelli-gence, recommendation systems, Explainable Artificial Intelligence (XAI), and educational analytics. However, the primary focus of existing studies has been on solving individual scheduling problems rather than developing an integrated academic management platform. This section presents a comparative analysis of the reviewed stud-ies by examining their algorithms, application domains, strengths, limitations, and research contributions.

Most survey papers emphasize the effectiveness of op-timization algorithms such as Genetic Algorithms, Sim-ulated Annealing, Particle Swarm Optimization, Tabu Search, Constraint Programming, Integer Programming, and Hybrid Metaheuristics for solving the University Course Timetabling Problem [1]–[6]. These techniques effectively satisfy hard constraints such as faculty con-flicts, classroom allocation, and timetable clashes while optimizing soft constraints including workload balanc-ing and faculty preferences. However, these approaches generally assume static scheduling environments and provide limited support for real-time timetable modifi-cations.

Research on mathematical optimization models has demonstrated improved scheduling quality by apply-ing Mixed Integer Linear Programming and constraint-based optimization techniques to synchronize course-work schedules and allocate institutional resources [7], [13]. Although these methods generate optimal or near-optimal solutions, their computational complexity in-creases rapidly with institutional size, making them less suitable for dynamic scheduling environments involving frequent timetable modifications.

Artificial Intelligence has introduced new opportu-nities for intelligent academic scheduling. Machine Learning-based scheduling frameworks and intelligent optimization techniques improve scheduling efficiency while reducing manual intervention [12], [14], [15]. Similarly, recommendation systems have been applied to improve educational decision-making by recommend-ing suitable academic resources using historical data, domain knowledge, and intelligent reasoning techniques [16], [17]. Nevertheless, existing recommendation sys-tems primarily focus on students rather than supporting teacher allocation, substitute recommendation, or insti-tutional staff scheduling.

Explainable Artificial Intelligence has emerged as an important research direction for improving transparency and user trust in AI-based systems [18]. XAI enables administrators to understand the reasoning behind au-tomated scheduling decisions, thereby increasing confi-dence in Artificial Intelligence-based academic manage- ment. Despite its advantages, Explainable AI has not yet been widely integrated into university staff scheduling and timetable management systems.

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Table 2 Comparison of Scheduling Algorithms Used in Reviewed Studies

Algorithm	**Research Papers**	**Solution Quality**	**Computation Time**	**Handles Hard Constraints**	**Handles Soft Constraints**	**Dynamic Scheduling**	**Explainability**	**Suitable for Our Project**
Genetic Algorithm (GA)	[1], [2], [3], [5], [6], [8], [10]	High	Medium	✓	✓	Partial	×	✓✓✓
Hybrid Genetic Algo-rithm	[1], [2], [6]	Very High	Medium	✓	✓	Partial	×	✓✓✓
Simulated Annealing (SA)	[1], [2], [3], [4], [6]	High	Medium	✓	✓	×	×	✓
Tabu Search (TS)	[1], [2], [3], [4], [6]	High	Medium	✓	✓	×	×	✓
Particle Swarm Opti-Mization (PSO)	[1], [2], [3], [6]	High	Fast	✓	Partial	×	×	✓
Ant Colony Optimiza-tion (ACO)	[1], [2], [3], [6]	High	Medium	✓	Partial	×	×	✓
Constraint Program-ming (CP)	[1], [3], [4]	Very High	Slow (Large Problems)	✓✓	Partial	×	✓	✓
Integer/Mixed Integer Programming (IP/MILP)	[1], [3], [4], [7], [15]	Optimal	Slow	✓✓	✓	×	✓	Partial
Rule-Based Scheduling	[9], [11], [12]	Medium	Fast	Partial	Partial	Partial	✓	Partial
Machine Learning	[11], [13], [16]	High	Medium	×	✓	Partial	Partial	✓✓
Knowledge Based Rec-ommendation	[17]	High	Fast	×	✓	✓	✓	✓✓✓
Explainable AI (SHAP, LIME)	[18]	Decision Support	Medium	N/A	N/A	N/A	✓	N/A
Learning Analytics Dashboard	[19]	Medium	Medium	×	✓	✓	Partial	✓

Educational analytics and dashboard systems fur-ther support institutional decision-making by provid-ing meaningful visualizations of academic performance, institutional workload, and scheduling statistics [19]. These systems improve monitoring and administrative efficiency but generally operate independently from in-telligent scheduling engines.

Overall, the reviewed literature indicates that most existing systems focus on individual research problems such as timetable optimization, recommendation sys-tems, Explainable AI, or educational analytics. Very few studies integrate these technologies into a unified aca-demic management platform capable of supporting AI-based staff scheduling, Genetic Algorithm optimization, intelligent teacher recommendation, dynamic teacher substitution, leave management, Explainable AI, Fire-base cloud synchronization, Android mobile applica-tions, and real-time class reminder notifications. There-fore, developing an integrated intelligent scheduling framework remains an important research opportunity for modern educational institutions.

Table 2 compares the optimization and Artificial In-telligence algorithms adopted in the reviewed literature. Genetic Algorithms are the most widely used optimiza-tion technique because of their ability to efficiently sat-isfy both hard and soft scheduling constraints while gen-erating high-quality timetables. Constraint Programming and Mixed Integer Linear Programming provide math-ematically

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optimal solutions but require higher compu-tational resources for large scheduling problems. Rule-based approaches offer fast execution but lack adapt-ability in dynamic environments. Recently, Machine Learning, Knowledge-Based Recommendation Systems, and Explainable Artificial Intelligence have emerged as promising approaches for intelligent academic decision-making. Based on the comparative analysis, integrating Genetic Algorithms with Explainable AI and intelligent recommendation systems provides a suitable foundation for the proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

➢ *Comparative Analysis of Reviewed Papers*

The comparison of various timetable generation tech-niques as shown in Table 1 reveals significant differences in terms of efficiency, flexibility, and scalability. Each method focuses on solving the scheduling problem from a different perspective, which results in varied perfor-mance outcomes.

➢ *Dataset Comparison*

The datasets reported across the reviewed literature can be broadly grouped into benchmark timetabling datasets, institutional academic datasets, educational datasets, and knowledge-based datasets. Survey stud-ies on university course timetabling commonly dis-cuss established benchmark datasets such as ITC2002, ITC2007, Curriculum-Based Course Timetabling (CB-CTT), Post-Enrolment Course Timetabling (PE-CTT), Udine, and Socha benchmark datasets [1]–[6], [10]. These datasets are useful because they provide standard-ized scheduling problems through which different opti-mization techniques can be compared. Several studies also consider real or institutional scheduling informa-tion, including course registrations, faculty assignments, instructor availability, classroom capacities, curriculum requirements, and institutional timetable records [7], [8], [12], [13]. Such datasets are more representative of practical academic environments because they con-tain the constraints encountered during actual timetable preparation.

Table 3 Dataset Comparison of Reviewed Papers

Ref.	Paper Title (Short)	Dataset Used	Dataset Type	Purpose
[1]	UCTP Survey	ITC2002, ITC2007, Udine, Purdue, Real University Datasets	Benchmark & Real-world	Survey and comparison of timetabling methods
[2]	Meta-Heuristic UCTP Survey	ITC2002, ITC2007, CB-CTT, PE-CTT	Benchmark	Review of optimization algorithms
[3]	Approaches for UCTP	ITC2002, ITC2007, Socha Benchmark, Real University Data	Benchmark & Real-world	Timetabling survey
[4]	Educational Timetabling	ITC2002, ITC2007, Examination & Curriculum Datasets	Benchmark	Benchmark evaluation
[5]	GA Survey	University Timetabling & Examination Timetabling Datasets	Benchmark	Review of GA techniques
[6]	Optimization Algorithms Review	ITC Benchmark & University Scheduling Data	Benchmark	Algorithm comparison
[7]	Coursework Timetabling	Institutional Coursework Scheduling Data	Real-world	Workload optimization
[8]	Personal Course Timetabling	Student Course Registration Records	Institutional Dataset	Personalized timetable generation
[9]	Scheduling Systems Survey	Multiple Institutional Timetabling Studies	Survey Dataset	AI scheduling review
[10]	Generic Algorithms Survey	ITC2002, ITC2007, Examination Timetabling Datasets	Benchmark	Generic timetabling evaluation
[11]	Smart Timetable Using AI	Institutional Timetable Records	Real-world	AI-based timetable generation
[12]	Automated Timetabling System	Faculty Availability, Classroom Allocation Records	Institutional Dataset	Automated timetable generation
[13]	ML Timetable Evaluation	ITC Benchmark Dataset	Benchmark	Timetable quality prediction
[14]	Fair University Scheduling	Pandemic Scheduling Scenarios & Classroom Capacity Data	Simulated Dataset	Fair scheduling optimization
[15]	ML Recommendation System	Student Academic Records & Learning History	Educational Dataset	Recommendation model
[16]	Knowledge-Based Recommended	Knowledge Graphs, Ontologies, User Preferences	Knowledge Dataset	Intelligent recommendation
[17]	Explainable AI	Benchmark Machine Learning Datasets	Benchmark	XAI evaluation
[18]	Learning Analytics Dashboard	LMS Logs, Academic Performance Records	Educational Dataset	Analytics and visualization
[19]	Cloud-Based Learning Platform	Cloud Database / Institutional Data	Cloud /Institutional Dataset	Cloud-based timetable & learning management

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In the recommendation and educational analytics do-main, the reviewed works use different forms of ed-ucational information. These include student academic records, course histories, learning assessment data, LMS interaction logs, knowledge graphs, domain ontologies, and user preference information [16], [17], [19]. These datasets support recommendation, personalization, ana-lytics, and knowledge-based decision-making. For Ex-plainable AI, benchmark machine-learning datasets and model outputs are commonly used to evaluate explana-tion techniques such as SHAP and LIME [18]. However, the literature indicates that there is limited availability of datasets specifically combining faculty availability, teacher expertise, workload, leave records, classroom availability, timetable constraints, and substitution deci-sions.

The comparison in Table 3 shows that benchmark datasets are widely used for evaluating timetable op-timization algorithms, whereas institutional and educa-tional datasets are more suitable for practical recom-mendation and analytics applications. A major limitation identified from the reviewed literature is the lack of a unified dataset combining staff scheduling, teacher ex-pertise, faculty availability, workload, leave information, classroom resources, and dynamic substitution require-ments.

➢ *Advantages and Limitations of Reviewed Studies*

The reviewed studies demonstrate that academic scheduling and educational management have been ap-proached using several optimization, artificial intelli-gence, recommendation, explainability, and analytics techniques. Optimization-based studies provide effective mechanisms for satisfying hard constraints and improv-ing soft constraints in timetable generation. Genetic Algorithms and other metaheuristic methods are partic-ularly useful for handling complex scheduling problems involving multiple constraints. However, many of these approaches primarily address static timetable generation and therefore have limited capability for handling real-time changes such as faculty leave, sudden substitutions, or changes in room availability.

Table 4 Advantages and Limitations of Reviewed Studies

Ref.	Major Advantages	Major Limitations
[1]	Comprehensive survey of UCTP algorithms and benchmark datasets; identifies research trends.	Focuses mainly on static timetable generation; no real-time scheduling or AI integration.
[2]	Reviews various metaheuristic optimization techniques and compares their performance.	Does not provide implementation or real-time scheduling support.
[3]	Provides strong theoretical foundation for university timetabling ap-proaches.	Does not consider AI, mobile applications, or cloud-based scheduling.
[4]	Reviews benchmark datasets and state-of-the-art optimization meth-ods.	Focuses on benchmarking rather than practical academic management systems.
[5]	Explains Genetic Algorithm concepts such as chromosome represen-tation, crossover, mutation, and fitness functions.	Does not include recent AI techniques or dynamic scheduling scenar-ios.
[6]	Compares multiple optimization algorithms and their strengths.	Limited discussion on intelligent recommendation and mobile integra-tion.
[7]	Produces mathematically optimal schedules and balances faculty work-load effectively.	Computational complexity increases significantly for large institutions.
[8]	Generates personalized timetables using a Micro Genetic Algorithm with fast convergence.	Limited to student timetabling; does not support faculty scheduling.
[9]	Reviews AI-based and hybrid scheduling approaches for higher edu-cation.	Limited discussion on Explainable AI and real-time academic man-agement.
[10]	Presents reusable optimization frameworks applicable to multiple timetabling problems.	Does not integrate intelligent recommendation or mobile technologies.
[11]	Demonstrates AI-assisted timetable automation and conflict reduction.	Limited experimental validation and not published in a major indexed journal.
[12]	Automates timetable generation and reduces scheduling conflicts.	Does not support teacher substitution or AI-based recommendations.
[13]	Uses Machine Learning to improve timetable evaluation efficiency.	Preprint only; lacks validation using real institutional datasets.
[14]	Optimizes fairness and classroom utilization under constrained envi-ronments.	Designed mainly for pandemic scenarios; not suitable for general academic scheduling.
[15]	Provides accurate Machine Learning-based recommendation models.	Focuses on students instead of academic staff scheduling.
[16]	Knowledge-based recommendations are transparent and solve the cold-start problem.	Requires manually maintained knowledge bases and domain rules.
[17]	Improves transparency and trust through Explainable AI techniques.	Does not specifically address academic staff scheduling applications.
[18]	Supports educational decision-making through dashboards and analyt-ics.	Focuses mainly on student analytics rather than staff scheduling and timetable management.
[19]	Improves scalability, accessibility, and resource sharing through cloud-based learning platforms.	No specific application for academic staff scheduling or timetable management.

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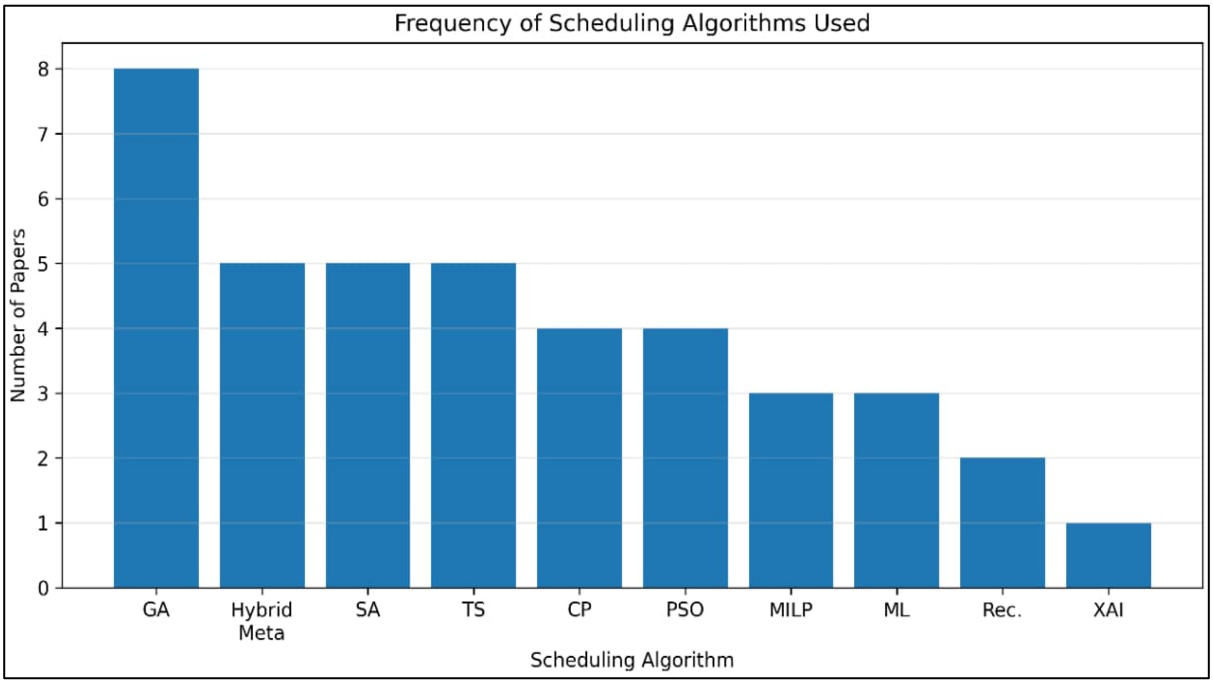

Fig 1 Frequency of Optimization Algorithms used in the Reviewed Literature. Genetic Algorithms are the Most Frequently Adopted Approach, Followed by Hybrid Metaheuristics, Simulated Annealing and Tabu Search

The frequency of scheduling algorithms employed in the reviewed studies is shown in Fig.1. Genetic Algorithms are the most frequently adopted optimization technique, followed by Hybrid Metaheuristics, Simulated Annealing, and Tabu Search. This indicates that evo-lutionary optimization techniques remain the dominant approach for solving university staff scheduling and timetabling problems.

Studies based on exact optimization methods pro-vide mathematically well-defined solutions and can ef-fectively handle constraints such as faculty workload, classroom capacity, and course requirements. Their ma-jor limitation is that computational complexity can increase as the size and number of scheduling con-straints increase. Consequently, they may become less suitable for frequent real-time timetable modifications. Recommendation-based approaches provide another im-portant advantage by enabling intelligent selection ac-cording to multiple factors such as expertise, prefer-ences, historical information, and contextual conditions. Knowledge-based recommendation can also reduce the cold-start problem because recommendations can be gen-erated using explicit domain knowledge. However, these approaches may require considerable effort to construct and maintain rules, knowledge bases, and domain on-tologies. Explainable AI approaches such as SHAP and LIME improve transparency by providing explanations for AI decisions. This is particularly important in aca-demic administration because administrators may need to understand why a particular teacher or scheduling option was recommended. However, explanation gener-ation can introduce additional computational overhead, and complex AI models may still be difficult to explain completely. Educational analytics and dashboard studies provide effective visualization and monitoring of aca-demic information. They support data-driven decision-making and help administrators understand institutional activities. However, many existing dashboards are pri-marily designed for student learning analytics and do not combine staff scheduling, faculty leave management, substitute allocation, workload balancing, and real-time notifications in a single platform. Overall, the reviewed literature demonstrates strong individual solutions for timetable optimization, recommendation, explainability, and educational analytics. However, these capabilities are generally studied separately. A major limitation iden-tified across the literature is the lack of an integrated system combining AI-based staff scheduling, dynamic teacher substitution, workload balancing, explainable recommendations, leave management, cloud data man-agement, and real-time mobile notifications. This gap motivates the development of the proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

From Table IV, it can be observed that existing stud-ies provide strong solutions for individual aspects of academic management, but they rarely combine these capabilities into a unified system. In particular, dynamic staff substitution, explainable teacher recommendation, workload balancing, leave management, and real-time mobile notification are not consistently integrated with automated timetable generation. Therefore, an integrated AI-based academic staff scheduling framework repre-sents an important research direction.

V. RESEARCH GAPS

The comprehensive review of the selected literature reveals that considerable progress has been achieved in university course timetabling, optimization algorithms, Artificial Intelligence, recommendation systems, Ex-plainable Artificial Intelligence (XAI), and educational analytics.

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➢ *Static Timetable Generation*

Most existing studies concentrate on generating static academic timetables before the beginning of a semester using optimization algorithms such as Genetic Algo-rithms, Constraint Programming, Integer Programming, and Hybrid Metaheuristics [1]–[10]. These approaches provide high-quality schedules but are not capable of efficiently handling real-time changes caused by faculty leave, classroom unavailability, timetable modifications, or emergency scheduling requirements.

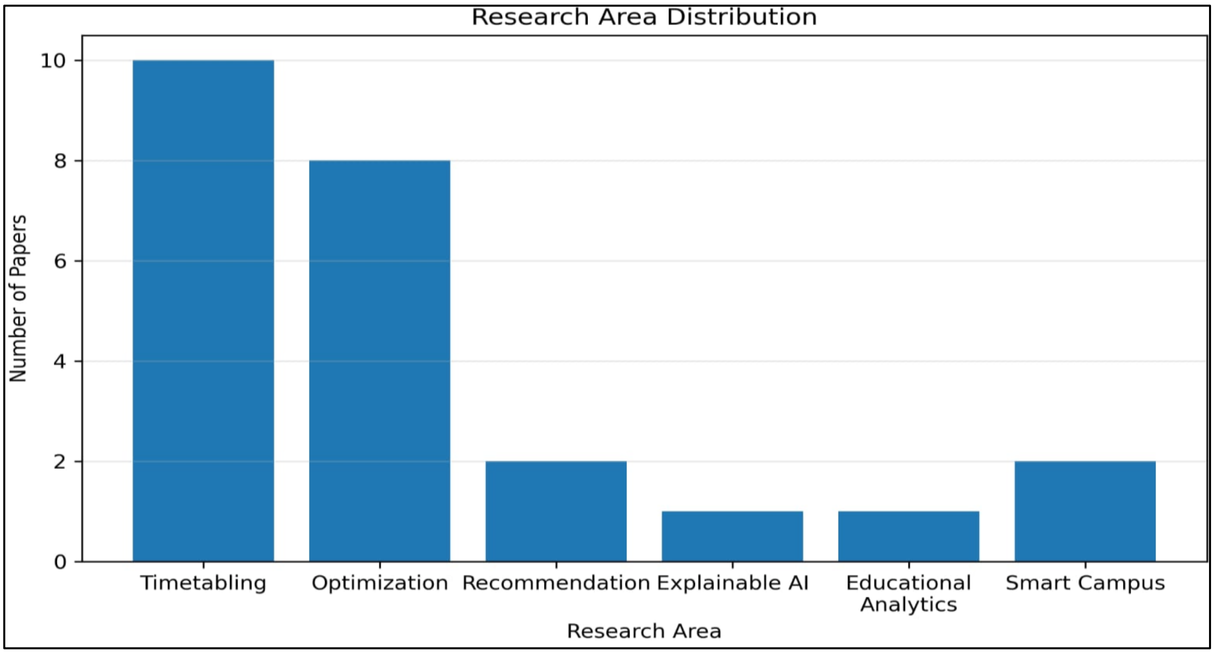

Fig 2 Distribution of Research Area covered by the Selected Studies, Include Timetabling, Optimization, Recommendation Systems, Explainable AI, Educational Analytics, and Cloud-Based Learning Platforms

Fig. 2 presents the distribution of research areas covered by the selected studies. Most of the reviewed papers focus on university timetabling and optimization techniques, whereas comparatively fewer studies inves-tigate Explainable AI, recommendation systems, and educational analytics. This highlights the opportunity for integrating these emerging technologies into intelligent academic management systems.

➢ *Lack of Intelligent Teacher Recommendation*

Although recommendation systems have been widely applied in educational environments, existing research primarily focuses on recommending learning materials, courses, or student learning paths [18], [19]. Very limited research has explored intelligent recommendation tech-niques for selecting suitable teachers based on subject specialization, workload, availability, teaching experi-ence, and institutional policies.

➢ *Absence of Explainable Scheduling Decisions*

Most Artificial Intelligence-based scheduling systems function as black-box optimization models, providing scheduling results without explaining the reasoning be-hind their decisions. Explainable Artificial Intelligence has been extensively studied in general AI applications [18], but its integration into academic staff scheduling remains very limited. Administrators require transpar-ent explanations to increase confidence in AI-generated scheduling decisions.

➢ *Limited Integration of Academic Management Mod-ules*

Existing scheduling systems mainly focus on timetable generation without integrating other essential academic management functions such as:

- Teacher Leave Management
- Automatic Substitute Teacher Allocation
- Faculty Workload Monitoring
- Classroom Availability Management
- Examination Scheduling
- Class Reminder Notifications

As a result, administrators are often required to use mul-tiple independent software systems to perform routine academic management tasks [1]–[15].

➢ *Limited Cloud and Mobile Integration*

Most reviewed scheduling systems are desktop-based or web-based applications with limited support for An-droid mobile platforms and cloud-based synchroniza-tion [9], [12], [13]. Modern educational institutions re-quire mobile applications capable of providing real-time timetable updates, instant notifications, and synchronized academic information through cloud services such as Firebase.

➢ *Lack of Unified Intelligent Academic Management Platforms*

One of the most significant research gaps identified in this survey is the absence of a comprehensive academic management system that integrates optimization algo-rithms, Artificial Intelligence, recommendation systems, Explainable AI, cloud computing, and educational ana-lytics into a single platform. Existing research generally investigates these

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technologies independently rather than combining them into an integrated solution [1]–[19].

➢ *Research Gap Addressed by the Proposed System*

Based on the identified limitations, the proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System aims to bridge the following research gaps:

- AI-based automated staff scheduling using Genetic Algorithms.
- Intelligent teacher recommendation based on exper-tise, workload, and availability.
- Dynamic teacher substitution during faculty ab-sence.
- Explainable AI to justify scheduling decisions.
- Firebase cloud synchronization for real-time aca-demic updates.
- Android-based academic management application.
- Real-time class reminder and timetable notification system.
- Integrated educational analytics dashboard for ad-ministrators.

The integration of these features into a single intelligent platform distinguishes the proposed system from existing academic scheduling solutions and addresses several important limitations identified in the reviewed literature.

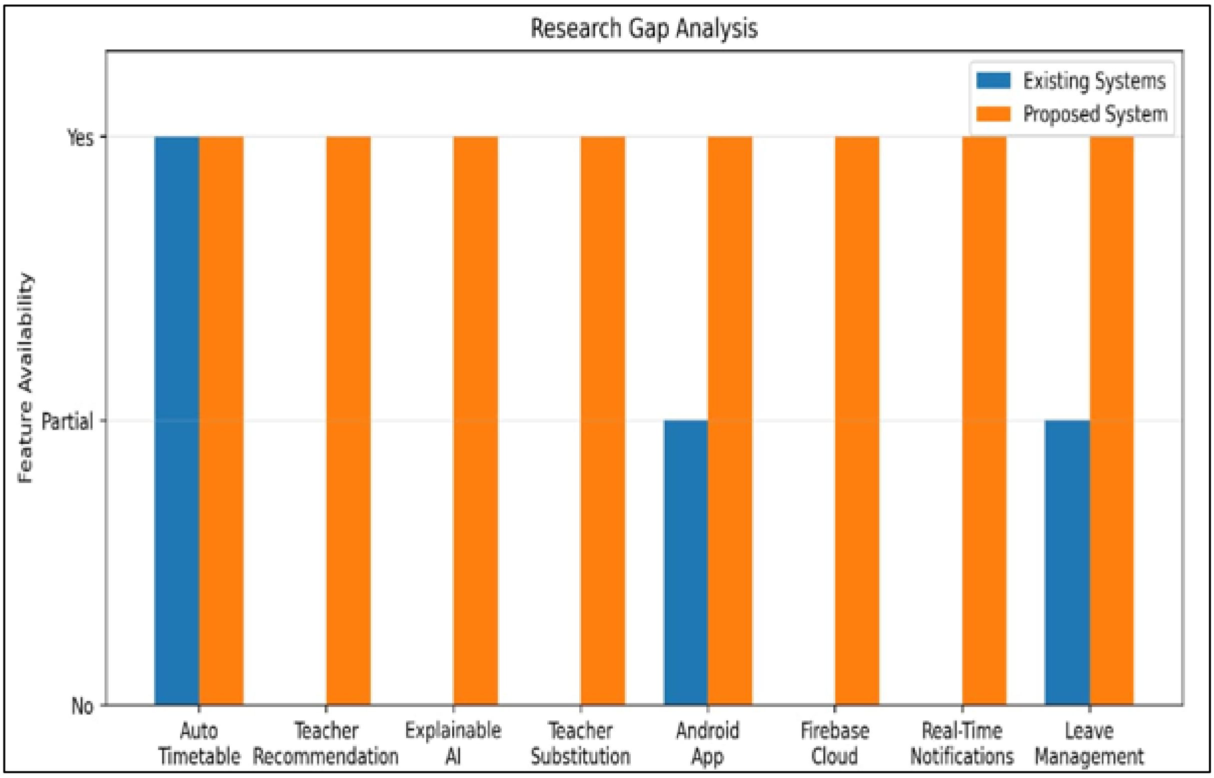

Fig 3 Comparison between Existing Scheduling Systems and the Proposed AI-Based Smart Scheduling and Class Reminder Notification System ,Highlighting Additional Features Such as Explainable AI, Teacher Recommendation, Firebase Synchronization and Real-Time Notification

Fig. 3 compares the capabilities of existing academic scheduling systems with those of the proposed AI-Based Smart Staff Scheduling and Class Reminder Notifica-tion System. Existing studies mainly concentrate on timetable generation, while the proposed system inte-grates Explainable AI, teacher recommendation, leave management, teacher substitution, Firebase cloud ser-vices, Android support, and real-time notifications. This comparison demonstrates the broader scope and potential contribution of the proposed system.

VI. PROPOSED ARCHITECTURE

The proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System integrates Artificial Intelligence, cloud computing, and mobile technologies to automate academic staff scheduling and class re-minder services. The architecture consists of four major components: the Android application, Firebase cloud backend, AI-based scheduling engine, and notification service. Users, including administrators, teachers, stu-dents, and substitute faculty members, interact with the system through the Android application. User authen-tication and data management are handled using Fire-base Authentication and Cloud Firestore. The AI engine applies Genetic Algorithms and recommendation tech-niques to generate optimized schedules, detect conflicts, recommend substitute teachers, and provide Explainable AI-based scheduling decisions. Finally, Firebase Cloud Messaging delivers real-time notifications and reminders to all users, ensuring effective communication and effi-cient academic management.

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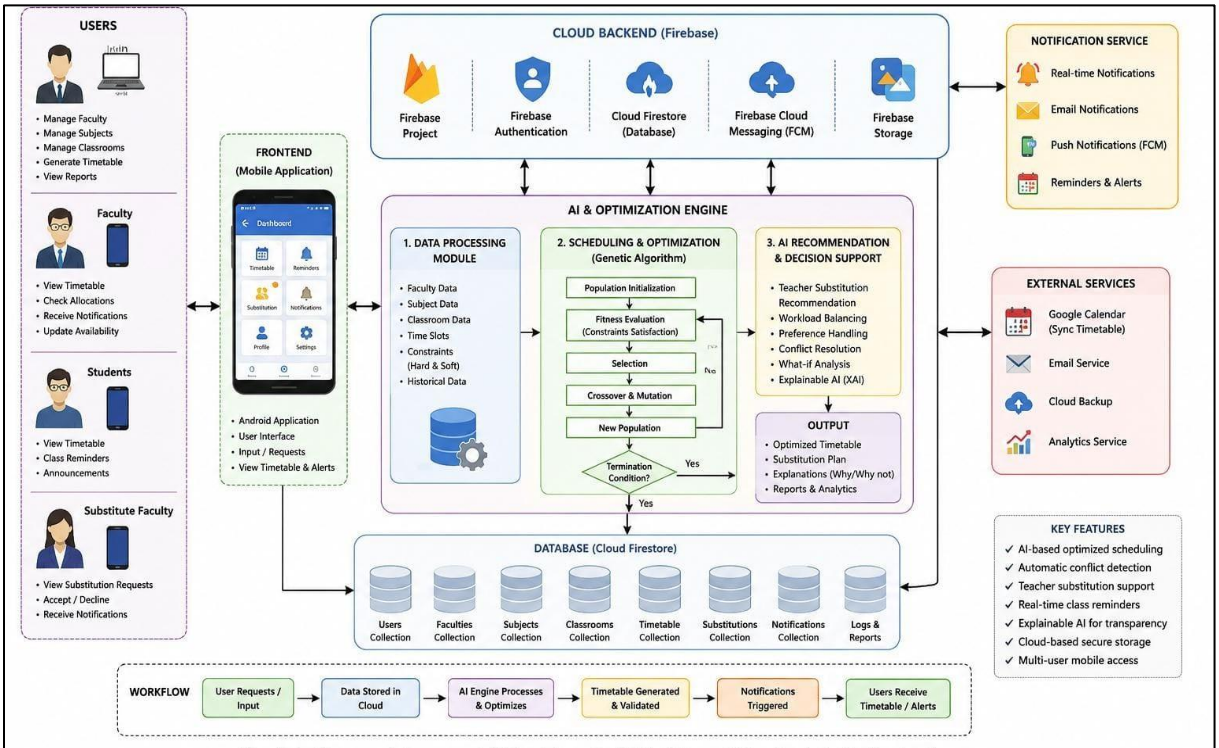

Fig. 4. Architecture of the proposed AI-Based Smart Staff Scheduling and Class Reminder Notification System.

Fig 4 Proposed Architecture of the AI-Based Smart Staff Scheduling and Class Reminder Notification System.

Fig. 4 illustrates the proposed architecture of the AI-Based Smart Staff Scheduling and Class Reminder Notification System. The system enables administrators, teachers, students, and the examination cell to access scheduling services through an Android application. User authentication and data storage are managed us-ing Firebase Authentication and Cloud Firestore. The AI Scheduling Engine employs Genetic Algorithms to generate optimized staff schedules, while the Teacher Recommendation Module identifies suitable substitute teachers based on availability, expertise, and workload. An Explainable AI (XAI) module provides transpar-ent scheduling decisions, and Firebase Cloud Messag-ing (FCM) delivers real-time timetable updates and reminder notifications. This integrated architecture en-hances scheduling efficiency, minimizes conflicts, and supports intelligent academic management. Fig. 4. Pro-posed Architecture of the AI-Based Smart Staff Schedul-ing and Class Reminder Notification System.

VII. CHALLENGES AND FUTURE RESEARCH DIRECTIONS

The comparative analysis of the reviewed literature indicates that significant progress has been made in university course timetabling, optimization algorithms, Artificial Intelligence, recommendation systems, Ex-plainable Artificial Intelligence (XAI), and educational analytics. Despite these advancements, several technical and practical challenges remain unresolved, limiting the deployment of intelligent academic scheduling systems in real-world educational institutions [1]–[19].

➢ *Dynamic Staff Scheduling*

Most existing timetabling systems are designed to generate static schedules before the commencement of an academic semester. These systems have limited capa-bility to adapt to real-time events such as faculty leave, emergency substitutions, classroom unavailability, or sudden timetable modifications [1]–[10]. Future research should focus on adaptive scheduling algorithms capable of updating timetables dynamically while minimizing disruption to existing schedules.

➢ *Intelligent Teacher Recommendation*

Current recommendation systems mainly support stu-dent learning or general educational decision-making rather than assisting academic administrators in selecting appropriate faculty members for teaching assignments or substitute allocation [16], [17]. Future systems should develop intelligent recommendation models that consider subject expertise, teaching experience, workload distri-bution, faculty availability, departmental requirements, and institutional policies when recommending teachers.

➢ *Explainable Artificial Intelligence in Academic Scheduling*

Artificial Intelligence-based scheduling systems often function as black-box decision-making models, making it difficult for administrators to understand the reason-ing behind scheduling decisions. Although Explainable Artificial Intelligence has gained significant attention in recent years, its application in academic scheduling remains limited [18]. Future scheduling systems should provide transparent explanations describing why a par-ticular teacher, classroom, or time slot has been selected, thereby improving administrator confidence and system reliability.

➢ *Cloud-Based and Mobile Academic Management*

Most reviewed scheduling systems are designed as standalone desktop applications or web-based systems with limited mobile accessibility [9], [12], [13]. Fu-ture academic management platforms should integrate cloud technologies, real-time database synchronization, Android applications, and mobile notification services to enable seamless communication among administrators, faculty members, and students.

➢ *Educational Analytics and Decision Support*

Although educational analytics dashboards provide valuable insights into institutional performance, they are generally implemented independently from timetable generation and scheduling modules [19]. Future research should integrate scheduling algorithms with educational analytics to enable real-time monitoring of faculty work-load, classroom utilization, timetable efficiency, leave statistics, and scheduling performance.

➢ *Development of Integrated Intelligent Academic Man-agement Platforms*

The most significant future research direction identi-fied in this survey is the development of a unified aca-demic management platform that integrates timetable op-timization, Artificial Intelligence, recommendation sys-tems, Explainable AI, cloud computing, educational an-alytics, and mobile technologies within a single frame-work. Such systems should support:

- AI-Based Staff Scheduling
- Genetic Algorithm-Based Timetable Optimization
- Intelligent Teacher Recommendation
- Dynamic Teacher Substitution
- Faculty Leave Management
- Explainable AI-Based Scheduling Decisions
- Firebase Cloud Synchronization
- Android Mobile Applications
- Real-Time Class Reminder Notifications
- Educational Analytics Dashboard

VIII. CONCLUSION

This literature survey presented a comprehensive re-view of recent research related to university course timetabling, staff scheduling, optimization algorithms, Artificial Intelligence (AI), recommendation systems, Explainable Artificial Intelligence (XAI), and educa-tional analytics. A total of nineteen selected research papers published in IEEE, Elsevier, Springer, ACM Digital Library, and other reputed journals were sys-tematically analyzed based on their methodologies, al-gorithms, datasets, advantages, limitations, and research gaps [1]–[19].

The reviewed studies demonstrate that optimization techniques such as Genetic Algorithms, Constraint Pro-gramming, Integer Programming, Particle Swarm Opti-mization, Simulated Annealing, Tabu Search, and Hybrid Metaheuristics have significantly improved timetable generation by reducing scheduling conflicts, balancing faculty workload, and enhancing resource utilization [1]–[11]. Furthermore, recent advancements in Artificial Intelligence, Machine Learning, recommendation sys-tems, and Explainable AI have introduced intelligent decision-support mechanisms that improve transparency, recommendation accuracy, and administrative efficiency [12]–[18]. Educational analytics and dashboard systems have also contributed to improved monitoring and in-stitutional decision-making through visualization of aca-demic information and performance indicators [19].

Despite these advancements, the literature indicates that most existing systems primarily address individual research problems rather than providing a comprehensive academic management solution. Important administra-tive functions such as intelligent teacher recommenda-tion, dynamic teacher substitution, faculty leave man-agement, Explainable AI-based scheduling decisions, Android mobile applications, Firebase cloud synchro-nization, and real-time class reminder notifications re-main insufficiently integrated within current scheduling systems. These limitations reduce the adaptability, trans-parency, and operational efficiency of existing academic scheduling platforms.

Based on the identified research gaps, this survey emphasizes the need for a unified AI-Based Smart Staff Scheduling and Class Reminder Notification System ca-pable of integrating Genetic Algorithm-based timetable optimization, intelligent teacher recommendation, Ex-plainable Artificial Intelligence, cloud-based synchro-nization, Android mobile applications, educational an-alytics, and real-time notification services into a single academic management framework. Such an integrated system has the potential to reduce administrative work-load, improve scheduling accuracy, support dynamic aca-demic environments, enhance decision transparency, and facilitate efficient communication among administrators, teachers, and students.

In conclusion, the findings of this literature survey provide a strong theoretical and technological founda-tion for developing next-generation intelligent academic scheduling systems. The insights obtained from the re-viewed studies will guide the design and implementation of the proposed system while contributing to future re-search in Artificial Intelligence-driven educational man-agement and smart campus technologies.

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