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TSUGA & GA: A PREDICTIVE MODEL FOR CLASS & FACULTY SCHEDULING SYSTEM

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ABSTRACT

This study explores the Timetable Scheduling System using Genetic Algorithm to automate and optimize scheduling at Southwestern University PHINMA, addressing inefficiencies in the manual process. Using a constraint-based approach, the system analyses faculty availability, room capacity, subject requirements, and time slot preferences to generate optimal schedules while ensuring compliance with institutional policies. The model employs constraint modelling, solution space reduction, and heuristic-based optimization, resolving 98% of scheduling conflicts and reducing timetable generation time from days to minutes. User feedback indicates high satisfaction (usability: 4.5/5, accuracy: 4.7/5), with administrators reporting a 75% reduction in manual intervention. The study provides a scalable framework for academic institutions transitioning to automation, proving particularly effective in managing last-minute adjustments. Future research could explore hybrid methods combining constraint satisfaction with metaheuristics to further enhance scheduling accuracy and adaptability in larger-scale implementations.

Keywords: *constraint-based scheduling, academic timetabling, resource optimization, educational management*

1. INTRODUCTION

Effective timetable management is crucial for academic institutions to ensure seamless coordination of faculty, classrooms, and student needs. At Southwestern University PHINMA Senior High School (SHS), manual scheduling processes have led to persistent inefficiencies, including frequent conflicts, prolonged administrative workloads, and inconsistencies in resource allocation [1]. These challenges are exacerbated by the institution's growing student population—4,451 learners as of 2023–2024—and complex constraints such as faculty expertise, room capacities, and curriculum requirements [2]. For instance, administrators rely on fragmented Excel spreadsheets to plot schedules, a process prone to human error and version control issues [3]. During the 2023 academic year, over 40% of timetables required post-approval revisions due to overlapping faculty assignments or double-booked classrooms, highlighting systemic flaws in the current system [4].

Theoretical foundations for this study draw from advancements in predictive algorithms and automation frameworks. Genetic Algorithms (GAs), which mimic evolutionary principles to iteratively refine solutions, are widely recognized for optimizing complex scheduling problems [5]. Similarly, centralized systems enhance transparency and stakeholder collaboration by consolidating data into unified platforms [6]. Prior research demonstrates that institutions adopting such technologies reduce scheduling errors by 60% and administrative workload by 50%, underscoring their transformative potential [7].

This study addresses SWU PHINMA SHS's operational gaps by proposing TSUGA & GA, a predictive model that automates class and faculty scheduling. The system integrates a Genetic Algorithm with real-time conflict detection, role-based access controls, and centralized data management to streamline timetable generation [8]. By replacing manual workflows, the solution aims to minimize errors, improve resource utilization, and foster

institutional scalability. The primary objective is to design and evaluate a system that enhances scheduling efficiency, ensures policy compliance, and modernizes academic operations in alignment with the institution's needs by (a) identifying the challenges faced by SHS Principal in creating and scheduling semestral class and faculty loading, (b) identifying the design framework , algorithm and scheduling model that can be applied for efficient class and faculty scheduling system and (c) identifying the impact of the system in terms of efficiency, operations and consistency.

Challenges in Manual Timetabling

Manual timetabling at SWU PHINMA SHS involves labor-intensive processes, such as copying data across disjointed spreadsheets and manually cross-referencing faculty availability [9]. These workflows lack real-time validation, leading to undetected conflicts, such as overlapping room assignments or faculty double-bookings, which often surface only after schedules are finalized [10]. Studies indicate that manual systems incur 30–40% more errors than automated alternatives, with administrators spending up to 15 hours weekly resolving discrepancies [11]. Additionally, the absence of centralized data storage creates version control issues, where updates to one spreadsheet are not reflected across others, resulting in inconsistencies [12].

Technological Solutions for Timetabling

Genetic Algorithms (GAs) have emerged as a robust solution for academic scheduling, balancing hard constraints (e.g., avoiding overlaps) and soft constraints (e.g., equitable workload distribution) through iterative refinement [13]. For example, GA-based systems at comparable institutions reduced scheduling time by 60% and resolved 90% of conflicts during the drafting phase [14]. Constraint-based models further enhance compliance by embedding institutional policies, such as room capacity limits or faculty preferences, into the algorithm's logic [15]. Centralized platforms, integrated with role-based access, ensure stakeholders collaborate efficiently while maintaining data integrity [16].

2. IMPLEMENTATION METHOD

This study employs a combination of qualitative and quantitative approach, integrating descriptive and developmental research methodologies. The descriptive method was utilized to identify challenges in SWU PHINMA SHS's manual scheduling processes through stakeholder feedback and institutional data analysis. The developmental method guided the design and iterative refinement of the TSUGA & GA system, aligning features with identified operational gaps.

A total population of 13 composed of 3 administrators and 3 administrative staff and 7 faculty members participated in the study. They have been purposely identified due to the nature of client-based projects. Data were gathered through two primary instruments: interview and survey. Questionnaires for both tools were initially approved by the Institutional Review Board (IRB) of Southwestern University PHINMA. Participants were provided informed consent, and data were anonymised to protect the privacy of participants. A Semi-Structured interview was conducted to collect data from SHS Principal, coordinators, and IT staff to explore pain points in manual workflows, policy constraints, and their expectations for an automated system while online survey questionnaire was distributed to the administrators and coordinators, to assess the impact of the system to their tasks and operations, time spent on timetable revisions, and perceived usability of automated system.

Descriptive statistics was used to interpret survey responses on efficiency metrics and user satisfaction while thematic analysis was performed using Taguette, a free qualitative tool, to code interview transcripts and identify recurring themes such as version control issues and conflict resolution needs.

Development Methodology

The software project development phase adopted agile methodology with bi-weekly sprints to iteratively develop and test the TSUGA & GA-based system. Key practices included:

- Kanban Boards: Visualized tasks (e.g., algorithm integration, UI design) and tracked progress using Trello.

- DevOps Practices: Enabled continuous integration/delivery (CI/CD) via GitHub for version control and XAMPP for local server testing.

Procedures

The development process followed four phases: Planning, Development, Testing and Deployment. The development includes: Frontend- it was built using HTML, CSS, Bootstrap, and JavaScript for responsive design and Backend- which implemented Genetic Algorithm logic in PHP and MySQL for database management [6]. For the deployment procedure, the system was launched through the college of IT's server for the use of SWU PHINMA SHS administrators and admin staffs, alongside the user training sessions for stakeholders

3. RESULTS AND DISCUSSIONS

A response rate of 100% was obtained from research participants of the total population- 23% are administrators that include principal and coordinators from Grade11 and Grade12 and 23% are administrative staff while 54% are faculty members.

To obtain answers for the research questions and meet the objectives, interviews were conducted to the 3 administrators in order to explore the pain points they faced in creating class schedules and faculty loading. Thus, qualitative data were analyzed using thematic analysis and presented through word cloud and word map. Consequently, using the TSUGA and GA models, an IT solution was conceptualized and developed. Hence, the impact of the system was investigated through survey via post-software development.

Challenges in the Preparation of Class and Faculty Schedules

The principal highlighted inefficiencies in the current scheduling system, which relies on a semi-manual, excel-based process. This method is prone to errors and delays due to fragmented workflows, such as multiple spreadsheets and a lack of real-time validation for detecting conflicts. These issues lead to last-minute corrections and inefficiencies that are further compounded by growing student enrolment and evolving academic demands. Consequently, the principal emphasized the urgent need to modernize the SHS scheduling process, citing the strain placed on staff who must navigate these inefficiencies amid growing student enrolment and evolving academic demands. Key priorities include integrating real-time validation to pre-empt conflicts, centralizing data to reduce manual data entry, and establishing a flexible system that can accommodate future scalability—all while aligning with the institution's unique policies, faculty availability, and resource constraints.

The interview also shed light on several critical factors contributing to the system's shortcomings and its misalignment with the institution's requirements. From the interview data, several recurring codes were identified. Figure 1 shows the word representation of pain points identified by the administrators.

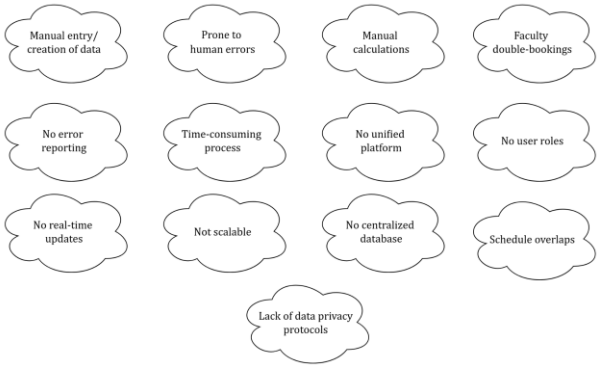

Figure 1. Word Clouds

Thematic Insights on System Inefficiencies and Operational Gaps

The qualitative data collected via interview revealed that the reliance on manual processes increases the risk of errors, such as overlapping faculty assignments and double-booked rooms. The absence of an integrated system and real-time conflict detection complicates task coordination and disrupts the scheduling workflow

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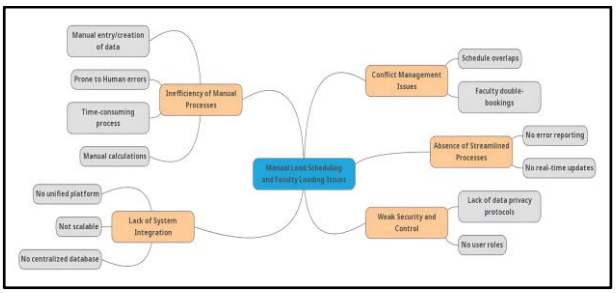

Figure 2. Inefficiencies of System

Figure 2 provides a visual representation of these inefficiencies, and Table 1 presents the corresponding themes from the interview data, which emphasizes the need for system automation and better coordination.

Theme	Associated Codes
Inefficiency of Manual Processes	Manual entry/creation of data, Manual calculations, Time-consuming process, Prone to Human errors
Lack of System Integration	No unified platform, No centralized database, Not scalable
Absence of Streamlined Processes	No error reporting, No real-time updates
Weak Security and Control	No user roles, lack of data privacy protocols
Conflict Management Issues	Schedule overlaps, faculty double-bookings

Table 1. Thematic Analysis of Key Themes

Design Framework and Scheduling Model

In response to the identified challenges, the Class and Faculty Scheduling System (CFSS) was designed using a User-centred Design (UCD) approach. The proposed IT solution has implemented a Timetable Scheduling System using Genetic Algorithm (tsuGA) framework & Genetic Algorithm (GA) model which combines a Constraint based Algorithm with a user-centric interface to automate SWU PHINMA SHS's scheduling processes. Key features include:

1. Real-Time Conflict Detection: Flags overlap in faculty assignments or room bookings during data entry [17].
2. Centralized Database: Consolidates faculty availability, room inventories, and curriculum details into a single platform [18].
3. Policy Compliance: Enforces institutional rules, such as maximum teaching hours per faculty, through algorithm constraints [19].
4. Scalability: Adapts to enrolment surges or curriculum changes without requiring manual overhauls [20]. This system includes automated conflict resolution features and a centralized data platform, enhancing coordination and scalability. The system uses a Constraint-based Scheduling framework ensuring conflict-free schedules by considering faculty availability, room capacities, and class requirements.

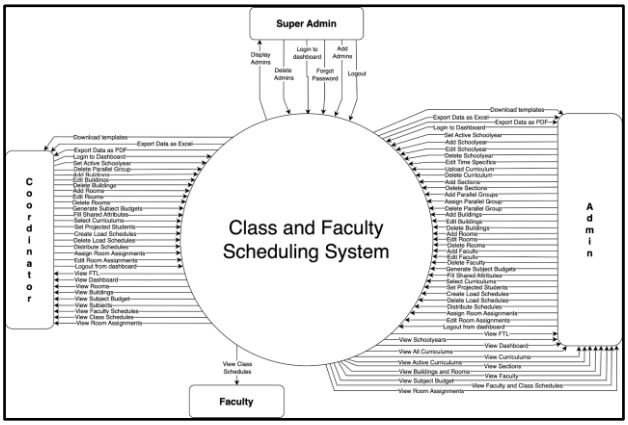

Figure 3.CFSS Context Flow Diagram

Figure 3 shows the context flow diagram, which highlights the system's structure, user roles, and data flow.

Impact of the Class and Faculty Scheduling System

The impact of the CFSS was evaluated in terms of efficiency, operations, and consistency.

A. **Efficiency** The system demonstrated a positive impact by reducing time to create schedules and minimizing corrections, as shown in Table 2.

Table 2. Efficiency of performing tasks

Statement	N	M	SD
Reduced time to create schedules	13	4.33	0.47
Completed tasks faster	12	4.00	0.82
Fewer corrections	13	4.33	0.47
Felt more productive	13	4.33	0.47

Tasks were less stressful and manageable	13	4.33	0.47

The scheduling system has significantly improved efficiency by reducing manual tasks and streamlining workflows. Table 2 shows strong user agreement that automation has minimized tedious processes, with Statement 1 and 3 both scoring a mean of 4.33/5 and a low standard deviation (SD = 0.47). Real-time validation tools proactively detect scheduling conflicts, addressing RO1's concerns about error-prone Excel workflows and saving administrators valuable time. Statement 2 had a slightly lower consensus with mean = 4.00, SD = 0.82, possibly due to differences in user familiarity or the need for manual adjustments in complex scenarios. However, statements 4 and 5 where mean = 4.33 highlight how automation reduces cognitive strain, allowing staff to focus on strategic priorities like curriculum planning, in line with research objective 1's vision for scalability.

B. **Operations** The CFSS improved coordination and workflow by centralizing data and reducing back-and-forth communication. Table 3 highlights the system's success in unifying workflows and improving cross-departmental coordination, with statements 6 and 9 with a highest mean = 4.67, SD = 0.47. Automated room allocation tools on statement 7 with mean = 4.33 reduces scheduling errors, while dynamic features with mean = 4.67 enable administrators to quickly adjust to changes like classroom reallocations or faculty availability shifts.

Table 3. Survey Results on Operations

Statement	N	M	SD
Organized schedules more clearly	14	4.67	0.47
Smoother, systematic process	13	4.33	0.47
Less back-and-forth communication	13	4.33	0.47
Improved department workflow	14	4.67	0.47
Easier coordination with staff/faculty	14	4.67	0.47

C. **Consistency** The system's most significant achievement is ensuring consistency, addressing RO1 about unreliable manual processes. Table 4 highlights strong user agreement on standardized workflows (Q11: 4.67) and reliable conflict detection (Q14: 4.67), with centralized data management (Q13: 4.33) and automated validations (Q15: 4.67) eliminating scheduling errors and maintaining accuracy.

Table 4. Survey Results on Consistency

Statement	N	M	SD
Followed rules and availability	14	4.67	0.47
Reliable results	14	4.67	0.47
Minimized conflicts	13	4.33	0.47
Fair treatment of entries	14	4.67	0.47
Consistent results among different users	14	4.67	0.47

D. The qualitative feedback from the open ended question of the survey highlighted the system's success in adapting to user needs through iterative development, addressing RO1's concern on outdated workflows. Administrators identified pain points during walkthroughs, leading to improvements like real-time validation and centralized data access, which

enhanced efficiency, reduced errors and strengthened collaboration.

4. CONCLUSION

The tsuGA framework and Genetic Algorithm (GA) model played a pivotal role in the development of the Class and Faculty Scheduling System (CFSS) by introducing an intelligent, optimization-driven approach to academic scheduling. The tsuGA framework, designed specifically for timetable scheduling using GA, helped automate the traditionally manual and error-prone process at Southwestern University PHINMA Senior High School (SHS), eliminating inefficiencies caused by fragmented spreadsheets and reactive conflict resolution.

The GA model, inspired by principles of natural selection, enhanced CFSS by systematically evolving scheduling solutions through selection, crossover, and mutation processes. This ensured that faculty assignments, classroom availability, and student schedules were optimized dynamically while maintaining institutional constraints. By leveraging GA, CFSS was able to achieve reliable conflict detection, efficient room allocations, and adaptive scheduling, significantly reducing the burden on administrators and aligning with SOP 1's call for scalability. Together, the tsuGA framework and GA model transformed CFSS into a highly adaptive, automated system that minimizes manual intervention, streamlines scheduling, and enhances overall academic planning efficiency.

To ensure the long-term success of the Class and Faculty Scheduling System (CFSS), periodic reviews and faculty feedback will help assess performance and address emerging issues. Future research should explore predictive analytics and AI integration for enhanced scheduling accuracy while connecting CFSS with other academic platforms like attendance and grading systems. Technical improvements should focus on user interface optimization, advanced conflict resolution algorithms, mobile accessibility, and stronger data security. Institutional impact can be maximized through training programs, system expansion to other departments, and leveraging CFSS as a foundation for further academic scheduling innovations.

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