ABUAD Journal of Engineering Research and Development (AJERD)
ISSN (online): 2645-2685; ISSN (print): 2756-6811

Volume 6, Issue 2, 143-156

Design and Implementation of an Examination Seating Arrangement Application to Curb Examination Malpractice

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Date Submitted: 06/09/2023
Date Accepted: 20/11/2023
Date Published: 01/12/2023

Abstract: *This research presents a web-based application developed to address the issue of "Giraffing" during examinations. The application in addition to the automating the examination seating arrangement so as to ensure that students enrolled in the same courses are not seated next to each other during the examination, it also includes a messaging feature that sends text messages to the students a five minutes before the start of the examination. These messages serve as reminders and provide important instructions, such as the examination time, location, and any specific materials required. By proactively communicating with the students, the application aims to minimize instances of lateness and confusion, ensuring that students are well-prepared and informed before entering the examination hall. The application, built using Laravel and Vue.js, incorporates key modules to facilitate the management and execution of the seating arrangement process. The greedy graph colouring algorithm and connection matrix served as the underlying methods for generating optimal seating assignments, effectively minimizing proximity among students with shared course enrolments. The message feature was facilitated by Termii API. To evaluate the application's functionality, thorough testing was conducted within the university environment. A selected number of students participated in the testing phase, ensuring the application's effectiveness and performance in real-world scenarios. Notably, the application successfully fulfilled all requirements, including the generation of a graphical representation of the seating arrangement and the timely delivery of text messages to students. These messages provided students with essential examination details and other relevant information, sent precisely five minutes before their scheduled examinations.*

Keywords: *Examination Misconducts, Greedy Graph Colouring Algorithm, Connection Matrix, "Giraffing", and, Seating Arrangements.*

1. INTRODUCTION

Examination misconducts, also known colloquially as cheating, is a persistent issue in the educational system worldwide. Acts such as "giraffing", where student taking the same course with other students who are seated in close proximity attempts to access information from one or more of them to his benefit, compromises the integrity of examination. Previous research efforts have explored solutions, including the utilization of the graph colouring algorithm to generate seating arrangements that minimize the risk of "giraffing" in examination halls [1]. Apart from "giraffing", different forms of examination misconducts have been identified, including leakage of examination information, impersonation, smuggling of foreign materials, copying, collusion, and digital cheating methods [2][3][4][6][7][8][9]. These malpractices undermine the fairness of assessments and the accurate evaluation of students' knowledge and skills. Several causes contribute to examination misconducts, such as the pressure to succeed, lack of preparation, unjust examination conditions, and lack of confidence in one's abilities [4]. To address this issue, various strategies have been adopted, categorized into psychological and technological approaches [5]. Psychological approaches include providing ample invigilators, scheduling examinations tightly, enforcing distance between candidates, and implementing gender-based separation. Technological approaches involve the use of tools such as Faraday cages, mobile phone detectors, jammers, biometric authentication, lockdown browsers, randomized test questions, and anti-plagiarism software [10][11][12][14][15][16][17][21][22]. However, despite the effectiveness of technological approaches in curbing examination malpractices, they are not without limitations. The following are some notable limitations of the technological approaches employed:

The Faraday cages and mobile phone detectors are effective in blocking and detecting the use of mobile phones and other electronic devices during exams [10][11]. However, they primarily address the issue of cheating with communication devices and do not fully eliminate other potential forms of cheating. And, Jammers are devices that deliberately transmit signals usually noise on the same radio frequency band as mobile phones, powerful enough to effectively disabling them within the jammer's range [12]. While jammers can prevent communication and internet access during tests, they may not address more sophisticated cheating methods or other potential forms of malpractice.

The use of biometrics, such as fingerprint or facial recognition, can verify the identity of candidates and reduce impersonation during examinations [14]. However, this approach may not address collusion within the test hall or prevent other forms of cheating. And, Lockdown browsers restrict students from accessing applications or websites other than the examination interface during the examination [21]. While this approach can prevent students from using online resources to cheat, it may not be effective against more advanced cheating methods, such as using smartphones or other devices.

Using a large pool of test questions and randomly selecting subsets for each student can prevent sharing of answers or the use of leaked questions [16]. However, implementing this approach may require significant resources, and it may not be feasible for all types of examinations. And, the Anti-plagiarism software compares student submissions with a database of previously submitted papers to detect instances of copying or paraphrasing [22]. While this approach can identify blatant plagiarism, it may not be as effective against subtler forms of cheating, such as collaboration or sharing of answers. In order to mitigate examination malpractice involving collaboration or sharing of answers, a web-based examination seating arrangement Application (App) that ascertains that examinees offering the similar course are not seated nearby was proposed by authors in [1]. The work in [1] was likened to the graph colouring and k-partition problem, and the Harmony Search Algorithm was employed to find solution to the problem. In contrast to the sole reliance on subject similarity for examination seating arrangement to address issues of collaboration and answer sharing within examination halls, the authors in reference [26] took a more comprehensive approach. They considered not only subject resemblance but also the physical spaces between examinees and tapped into the realm of human imagination to determine the most suitable and desirable seating arrangement. The study in [26] harnessed the power of the Evolutionary Genetic Algorithm to swiftly identify the most favourable solutions for this problem. While the contributions of [1] and [26] have significantly contributed to the effective separation of seats for examinees taking similar subjects in examination halls, they did not address the allocation of supervision duties to invigilators. To rectify this, the authors in reference [27] put forth an application designed to automate both the examination seating arrangement and the allocation of invigilation duties. Despite the elegance of the applications proposed in [1], [26], and [27], it is worth noting that they lacked a crucial functionality, which is the ability for examinees to remotely access their assigned seat numbers. Therefore, the proposed app in this study, in addition to the automating the examination seating arrangement so as to ascertains that examinees offering the similar course are not seated in close proximity, the app also includes a messaging feature that sends text messages to the students a five minutes before the start of the examination. These messages serve as reminders and provide important instructions, such as the examination time, location, and any specific materials required. By proactively communicating with the students, the app aims to minimize instances of lateness and confusion, ensuring that students are well-prepared and informed before entering the examination hall.

The developed app securely stores and handles student contact information, such as registered mobile numbers, ensuring compliance with privacy regulations and data protection policies. The messaging module within the app allows administrators to compose customized text messages, which can be sent to all students or specific groups, facilitating effective communication between the examination administration and the students.

By combining the connection matrix, graph colouring algorithm for seating arrangement optimization and the text messaging feature for timely communication, the developed app offers an integrated solution that addresses both psychological and technological aspects of combating examination malpractices. This comprehensive approach aims to create a supportive and organized examination environment, promoting fairness, integrity, and accurate evaluation of students' knowledge and skills. Through the implementation of this app, educational institutions can take a proactive stance in curbing examination malpractices, fostering a conducive and trustworthy assessment environment for students.

The residuum of the paper is unionized as follows. The methods and materials that were employed for the implementation of the proposed app are demoed in section 2. Section 3 is devoted to the discussion on the results obtained when the proposed app was tested in the field. Lastly, in section 4, some ratiocination is presented.

2. METHODOLOGY

2.1 Problem Formulation

The Examination Seating App aims to address the persistent issue of examination malpractice by developing an advanced seating arrangement system that utilizes the greedy graph colouring algorithm. The primary objective is to create a seating arrangement in which students taking the same course are not seated adjacent to each other, thus minimizing the risk of collusion and cheating during examinations. The problem can be formulated as follows: Given a set of students and a set of courses, the goal is to partition the students into subsets, each representing a seat, in such a way that students enrolled in the same course are not seated next to each other. This problem can be said to be analogous to the graph colouring problem. In the problem, the undirected graph G that has vertices V and edges E denotes the examination hall H that has seats S for a set of students that are doing more than two courses at a time and connectivity C;

$$H(S, C) = G(V, E) \quad (1)$$

And according to [23] , [24] and [25], this kind of the graph colouring problem is nondeterministic polynomial time complete (NPC); and the optimal solution to the NPC is to find the minimal and proper colourings (chromatic number) $X(G)$ [23] for the G viz:

$$X(G) = min\{k: P(G, k) > 0\} \quad (2)$$

In Equation (2), k denotes the numbers of available colours; while, $P(G, k)$ stands for the chromatic polynomial that counts the number of k colourings of G [23] [24]. A graph is $k - chromatic$ if $X(G) = k$. To solve this problem in this study, the algorithm proposed by [23] was adopted; where, connection matrix was utilized to colour undirected G. The connection matrix for the G with n vertices is a $n \times n$ matrix; whose entry seat (i, j) S_{ij} [23] is defined as

$$S_{ij} = \begin{cases} 1; & if \;\; i^{th} \; and \; j^{th} \; are \; connected \\ 0; & Otherwise \end{cases} \tag{3}$$

With the help of the connection matrix, each vertex neighbours (N) and non-neighbours (NN) were obtained with degree of each vertex [23].

2.2 Populating the Connection Matrix and Applying Greedy Colouring Algorithm

The procedure as proposed in [23] for the purpose of populating the connection matrix and applying Greedy colouring algorithm for a given G (V, E) is as following:

Step 1: Compute the total vertices n in G.
Step 2: Based on Equation (3), build a $n \times n$ connection matrix.
Step 3: Compute the degree of each node employing the information gotten in Step 2.
Step 4: Identify and pick the maximum degree node in Step 3. Assumed that the node is S_x, and its NN is S_y; use the same colour to colour S_x and S_y.
Step 5: Is S_x and S_y have common vertices? Yes, then use different colour to colour S_y.
Step 6: No, then use the same colour to colour these vertices.
Step 7: Is S_x has other new N? Yes, then go to step 8; else take new NN as the NN of S_y and go to step 8.
Step 8: Is the new NN and previous NN are adjacent? Yes, then colour new NN with different colour other than S_x; else colour new NN with colour of S_x.
Step 9: Is the new NN adjacent to any coloured vertices or to any previous NN? Yes, then use different colour to colour it.
Step 10: Are all vertices coloured? Yes, then go to step 12.
Step 11: No, Go to step 4.
Step 12: Return G.

2.3 Populating the Connection Matrix and Applying Greedy Colouring Algorithm

The system aims to automate the process of generating seating arrangements for examinations and notifying students about their assigned seats.

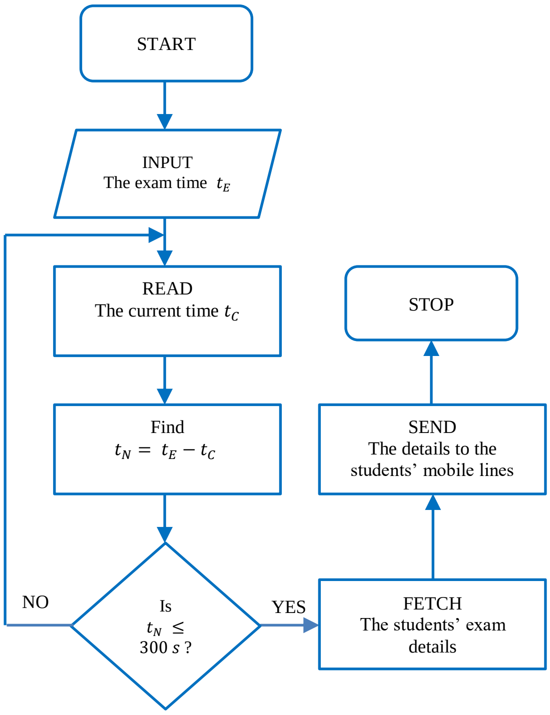

Figure 1: Flowchart for SMS API notification

The short message service SMS notification feature plays a crucial role in ensuring that students receive timely information about their seating details. The procedure of implementing SMS notification is presented in Figure 1.

2.4 Materials and Implementations

2.4.1 Specifications

The specification of the developed application is presented in Figure 2.

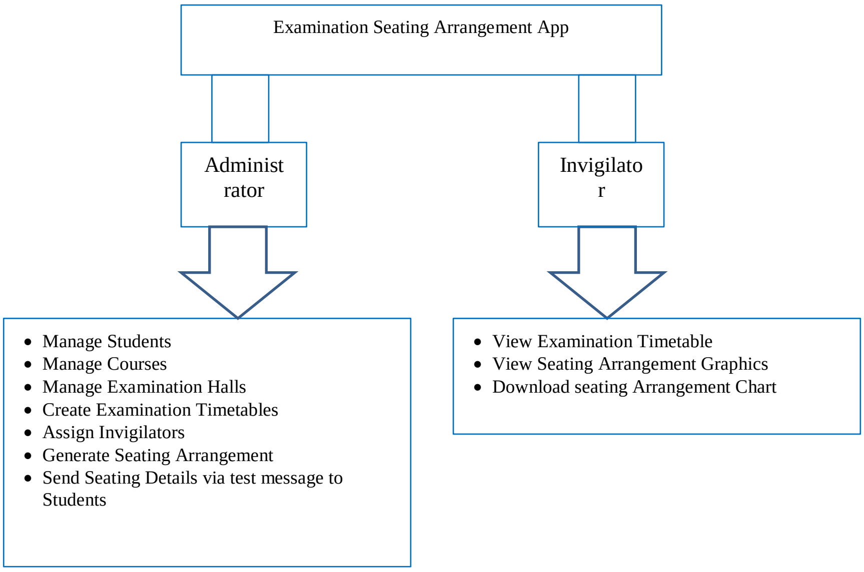

Figure 2.0: High level abstraction view of the application

2.4.2 Materials and Implementations

1. **Data base management system (DBMS):** In order to specify, control, recall, and oversee data in a database; a DBMS is needed. The DBMS that was utilized in this study was MySQL and a schema was created with 10 tables; which are presented in Tables 1 through 10. The database schema for this work was meticulously designed to meet the specific requirements of the proposed app. It comprises ten essential tables, each serving a distinct purpose and contributing to the overall functionality of the system. This structured database underpinned the successful implementation of the proposed web-based examination seating arrangement app. These tables are essential components of the application's schema, as they hold the data that is necessary for various aspects of the application's operation. They represent different data categories, such as student details, registration information, course allocation, seating arrangement, and text message notification. Furthermore, the results derived from these tables are instrumental in assessing the performance and functionality of the app. By analysing the data presented in these tables, insights into how the app is processing and managing student information, seating arrangements, and other related data are gained.

Table 1: Users table

Column	Type	Function
Id	bigint(20)	This is generated by the system as a unique identifier for each coordinator.
Name	varchar(255)	This holds the surname of each coordinator.
Email	varchar(255)	This holds the email of each coordinator.
password	varchar(255)	Keeps the user account safe

Table 2: Courses table

Column	Type	Description
Id	bigint(20)	This is generated by the system as a unique identifier for each course.
Name	varchar(255)	This holds the course title for each course.
Code	varchar(255)	This holds the course title for each course.
department	varchar(255)	This holds the department that owns the courses

Table 3: Examinationtimetable_courses table

Column	**Type**	**Description**
Id	bigint(20)	Unique identifier
examination_timetable_id	bigint(20)	This holds the id of the exam timetable to be executed
course_id	bigint(20)	This holds the course identifier of the courses to be written

Table 4: Course_Examination_hall table: This table joins both the examination hall to the courses to be written there

Column	**Type**	**Description**
Id	bigint(20)	Unique identifier
course_id	bigint(20)	identifiers of the courses to be written
examination_hall_id	bigint(20)	the hall identifier to be used

Table 5: Courses_student table: It joins the courses table together to see the students doing a particular course

Column	**Type**	**Default**
Id	bigint(20)	The unique identifier of each record in the table
course_id	bigint(20)	The course that each student is offering
student_id	bigint(20)	The student identifier for each course

Table 6: Examination hall table

Column	**Type**	**Default**
Id	bigint(20)	Unique identifier
Name	varchar(255)	hall name
seating_capacity	int(11)	hall capacity
Rows	int(11)	number of rows
columns	int(11)	number of columns

Table 7: Examination_Hall and examination timetable, this table joins both tables together

Column	**Type**	**Description**
examination_hall_id	bigint(20)	The hall id uniquely identifying the halls in the examination_hall table
examination_timetable_id	bigint(20)	The examination timetable id uniquely identifying each timetable

Table 8: Examination timetable table

Column	**Type**	**Description**
Id	bigint(20)	The unique identifier for each record
course_code	varchar(255)	The course codes of the courses to be written
course_title	varchar(255)	The course titles of the courses to be written
exam_date	Date	The Exam date
exam_start_time	Time	The examination start time
exam_end_time	Time	The examination end time
examination_hall_id	bigint(20)	The examination hall identifier

Table 9: Examination_timetable_course table: This table joins both course and examination timetable together

Column	**Type**	**Description**
Id	bigint(20)	The unique identifier in this table
examination_timetable_id	bigint(20)	The examination timetable record identifier
course_id	bigint(20)	The course identifiers for the timetables

Table 10: Seating arrangement table: It holds all the details of the students after the seating arrangement has been generated by the graph colouring algorithm

Column	Type	Description
Id	bigint(20)	The unique identifier for each seating arrangement pattern
student_id	bigint(20)	The student for each seating pattern
examination_hall_id	bigint(20)	The examination hall identifier
seat_number	varchar(255)	The seat label for each student
examination_timetable_id	bigint(20)	The examination timetable identifier
Color	varchar(50)	The department allocated to the seat
hall_name	varchar(255)	The name of the hall where the examination is to be written
Course	varchar(255)	The course to be written
course_code	varchar(255)	The course code of the course to be written
student_name	varchar(255)	The name of the student allocated to the seat
phone_number	varchar(110)	The phone number of the student to send the text messaging notification
Processed	Tinyint(1)	It acts as a status manager to check if the student has been sent the SMS notification

2. **Termii:** The SMS notification feature plays a crucial role in ensuring that students receive timely information about their seating details. The text messaging functionality in the developed application is implemented using the Termii API. Termii is a popular text messaging API provider that offers a robust and reliable solution for sending SMS messages programmatically. The implementation of the text message notification feature includes the technology stack, integration with external services, and the overall workflow.

i. **Technology stack:** The implementation of the SMS notification feature utilized various technologies and frameworks, including:

a. Laravel: The PHP framework used for developing the Examination Seating Arrangement System.
b. Termii: An external service provider that enables SMS communication through an API.
c. MySQL: The database management system employed to store student details, seating arrangements, and exam information.

ii. **Integration of termii with external services:** In this sub-section, we will explore how Termii works, its interaction with the proposed application, and the key components involved in enabling text messaging.

a. API Registration and Authentication: To utilize the Termii API, an account was created on the Termii platform. Upon registration, an API key that serves as the authentication mechanism for accessing the developed application's Termii API was obtained. This API key allows the application to securely communicate with the Termii API endpoint. The registration provides a custom base URL found in the dashboard of the developer.
b. API Endpoint: Termii provides a RESTful API interface that is accessed via a specific endpoint URL. In our implementation, we interact with the Termii API by sending HTTP requests to the https://api.ng.termii.com/api/sms/send endpoint. This endpoint is specifically designed for sending SMS messages.
c. Sending SMS Messages: To send a SMS message using the Termii API, a HTTP POST request to the Termii API endpoint was constructed. The request includes the necessary parameters, such as:
a. to: The mobile line of the recipient.
b. from: The mobile line or ID of the sender.
c. sms: The content of the message.
d. api_key: The unique API key provided by Termii.
e. channel: The messaging channel sets to 'generic'.
f. type: The message type sets to 'plain' for plain text messages.

d. API Request: The Guzzle HTTP client library in Laravel was utilized to send the HTTP POST request to the Termii API endpoint. The request is made with the appropriate headers and JSON payload, containing the SMS message details as mentioned above.
e. API Response: After the Termii API processes our request; it returns a response back to our application. The response is typically in JSON format and includes relevant information about the status of the request. We can access the response's status code, success or error indicators, and any additional data provided by the API.
f. Handling the Response: In our application, we handle the Termii API response by parsing and processing the JSON response received. We check the response status code and any error messages returned to determine the success or failure of the SMS message sending process. Based on the response, we can display appropriate feedback to the user or perform further actions in our application.
g. The integration of the Termii text messaging API enables us to send SMS notifications to our students after generating the seating arrangement. By utilizing Termii's powerful API, we ensure that students receive their seating details in a timely and efficient manner, mitigating the problem of giraffing and maintaining a controlled exam hall environment.

iii. **Workflow of SMS notification feature:** The implementation of the SMS notification feature followed a structured workflow to ensure the accurate and timely delivery of seating information to students:

a. The developed code using Figure 1.0 fetches the student data and seating arrangements for the specified timetable.
b. It checks if an SMS notification has already been sent to each student's mobile line. If so, it skips sending the SMS notification for that student.
c. The message content is customized based on the student's details.
d. The Guzzle HTTP client is used to send a POST request to the Termii API endpoint (https://api.ng.termii.com/api/sms/send). The request includes the necessary parameters, such as the recipient's mobile line, sender ID, message content, API key, channel, and type.
e. The response from the Termii API is checked to ensure the SMS was sent successfully (based on the response status code). If it was, the sent notification status can be saved to the database (in this case, the processed column in the seating_arrangements table is updated).
f. Finally, a redirect back to the seating arrangement page with a success message is performed.

While implementing the SMS notification feature, data privacy and security were given utmost importance. The following measures were taken to protect student information:

a. Encryption: Sensitive student data, such as mobile lines and examination details, were encrypted to prevent unauthorized access.
b. Access Control: Role-based access control mechanisms were implemented to restrict access to student information and the SMS notification feature.
c. Compliance: The system adhered to relevant data protection regulations and guidelines to ensure compliance and safeguard student privacy.

iv. **Testing and quality assurance:** To ensure the effectiveness and reliability of the SMS notification feature, comprehensive testing and quality assurance processes were employed. This involved:

a. Unit Testing: Individual components, such as SMS generation and Termii integration, were tested to verify their functionality.
b. Integration Testing: The integration between the Exam Seating Management System and the Termii service was thoroughly tested to ensure seamless communication.
c. User Acceptance Testing: A group of selected students participated in the testing phase to provide feedback on the SMS notification feature's usability and accuracy.

v. **Backend and frontend frameworks for the proposed application:** Apart from the Termii Messaging API Service that was used to send the text message notification; other backend for the building the web application was Laravel framework, which was used to create APIs that retrieve data from the database, and vue js, bootstrap for the frontend functionality.

2.4.3 Implementation

The strategy to implementation followed a separation into two design layers of the targeted project: The data layer and the web administration layer. The data layer consists of DBMS, which records, stores and manages the schema of projects, user data, hall data, Invigilator data and student data. The DBMS consists of data layouts. The web administration uses the API to communicate with the backend. Only administrators can access the fundamental data of the data layer (i.e. performing operations on the hall, user and student data) as shown in Figure 3 Web management includes a webpage which provides an interface for the administration of resources by the administrator.

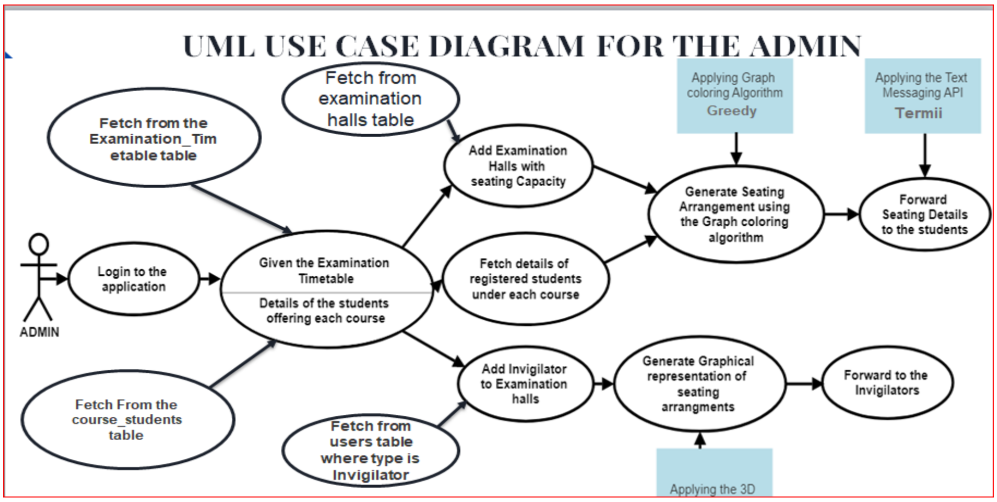

Figure 3: The UML case activity for the Administrator

The administration user can handle invigilators' data, students' data, and halls' data. He (she) also has the authority to give tasks to various coordinators. The administration user may also allow user access to non-accessed coordinators; and, for official reasons, he (she) can disable a coordinator.

2.4.4 System Requirements for the Examination Seating Arrangement Application

To run the proposed app so as to manage student seating arrangements for examinations while employing a greedy colouring algorithm and SMS notifications, it is crucial to ensure that the system meets the following requirements:

a. Operating System: The application is platform-agnostic and can run on Windows, macOS, or Linux, making it accessible across various environments.
b. Web Server: A web server supporting PHP, such as Apache or Nginx, is essential. For development, Laravel's built-in server suffices.
c. PHP: Employ the latest stable PHP version, PHP 7.4 or PHP 8.0, with required extensions, for example, PDO, OpenSSL, and Mbstring for Laravel compatibility.
d. Database: Choose a suitable database system, like MySQL or PostgreSQL, and ensure proper server configuration to store student data and seating arrangements.
e. Composer: Utilize Composer, a PHP package manager, for dependency management within the Laravel ecosystem.
f. Text Messaging Service: Integrate with a text messaging service provider (e.g. Termii) to enable SMS notifications for students regarding their exam seating.
g. Hardware Requirements: While the exact hardware specifications depend on usage and concurrency, a basic development system should possess: A dual-core processor or superior, 4GB of RAM or more; SSD storage for enhanced data access; and an internet connection to access external services like SMS gateways.

3. RESULTS AND DISCUSSIONS

3.1 Results and Discussions

With the objective of establishing the performance of the developed application, the details of a total of two hundred and fifty students that are doing eighteen different courses, and three members of the staff of the Faculty of Engineering, University of Lagos were registered in the proposed application as examinees and invigilators respectively. And the chosen venue of the examination for the demonstration is the Faculty of Engineering Lecture Theatre, University of Lagos, and Lagos, Nigeria; which has a seating capacity of two hundred and fifty.

Once a registered examination administrator launches the developed App, he would see the homepage which is presented in Figure 4; and upon clicking on the login button, Figure 5, login page, would pop-up. Once the examination administrator is able to login it takes him (her) to the custom home page for the administrator in Figure 6. The administrator is able to carry out some operations because he (she) has the user access right to do so. The addition of invigilator is done by the examination administrator; he (she) is the one in charge of adding invigilators and assigning them to their work post.

To add an examination hall into the database, the administrator has to input the following details which are important for the algorithm: The hall name, seating capacity of the hall, number of rows and column has shown in Figure 7.

Once the examination hall has been created, the examination administrator also has to assign invigilators to the hall that has been created has shown in Figure 8. To generate seats, the examination administrator has to click on Generate Seating Arrangement button as illustrated in Figure 9. He (she) is able to view a graphical representation of the seating arrangement has shown in Figure 10. The student is able to view the text message (Figure 11) on his (her) device after the administrator forwards the text message to the students by pressing the send SMS Notification button in Figure 9.

Additionally, on the Figure 9, examination timetable index page, there is the 'Fetch SMS Notification Status' button; which provides the administrator with the ability to check the status of sent text messages. This page consists of the student's seating details, the text message sent and the status of the message sent as presented in Figure 12.

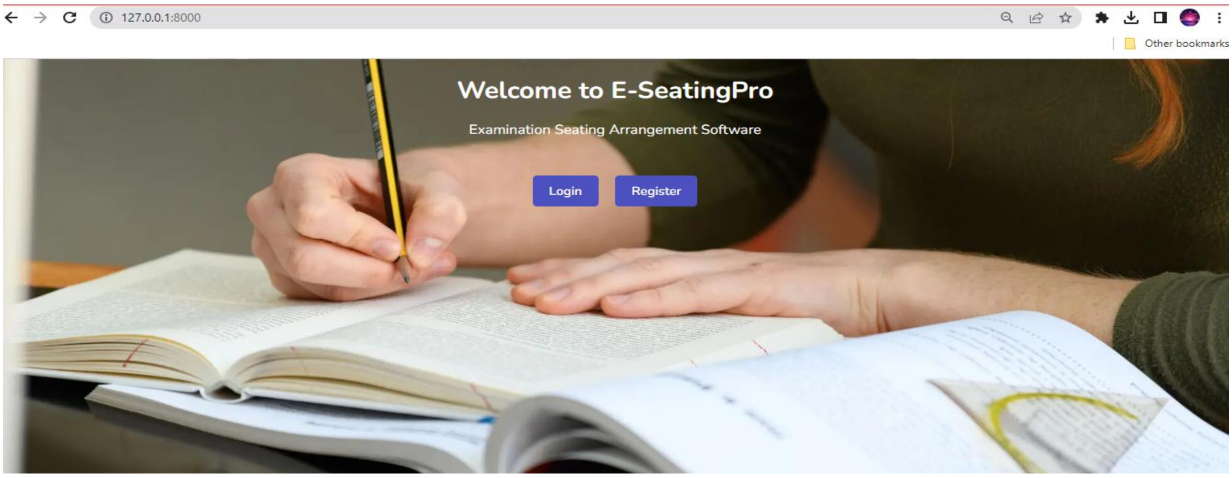

Figure 4: Homepage

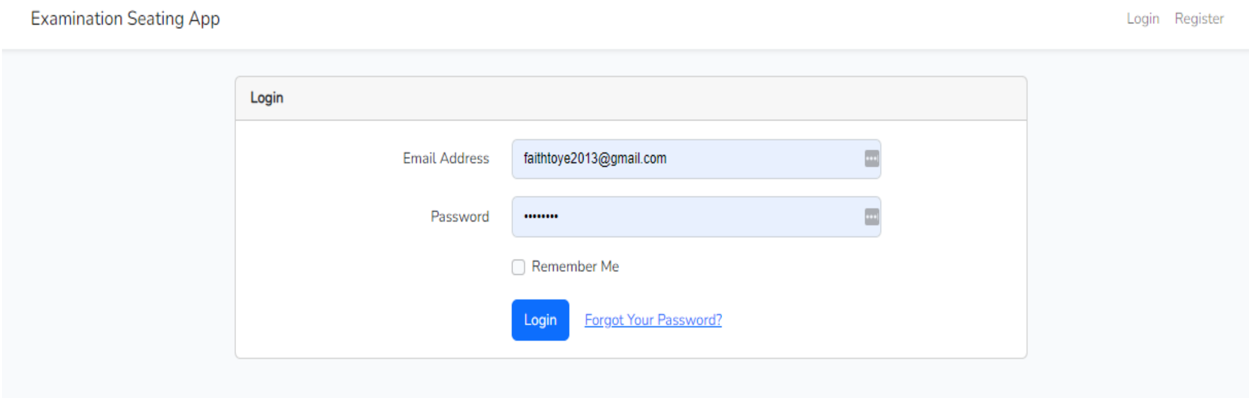

Figure 5: Login page

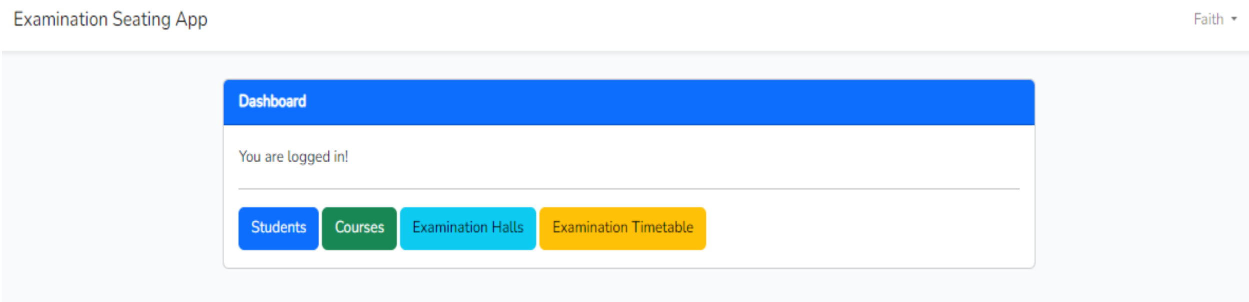

Figure 6: Admin homepage

Figure 7: Examination hall details page

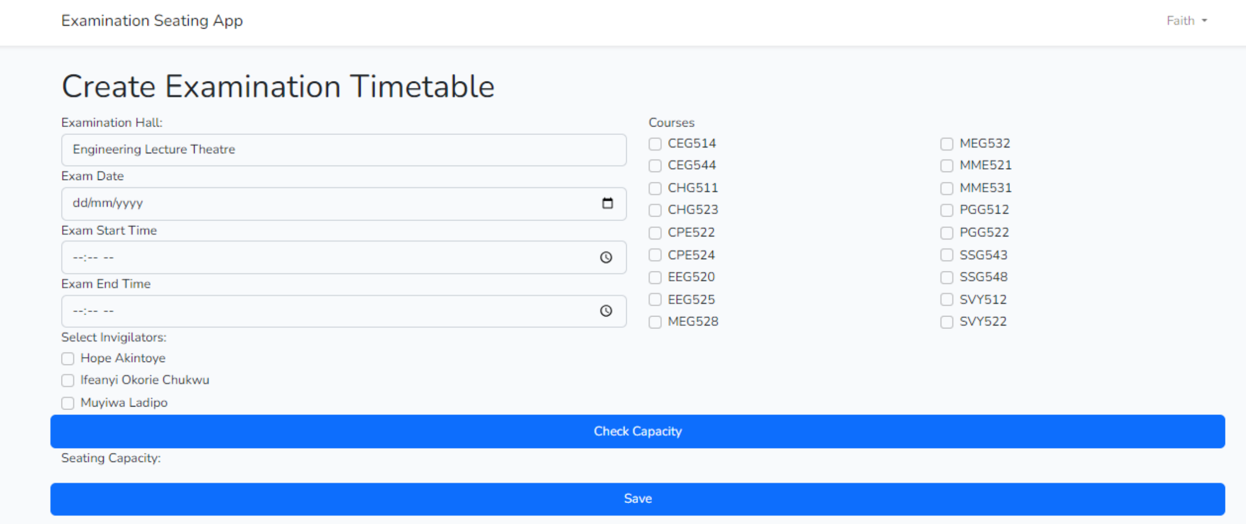

Figure 8: Examination timetable creation page

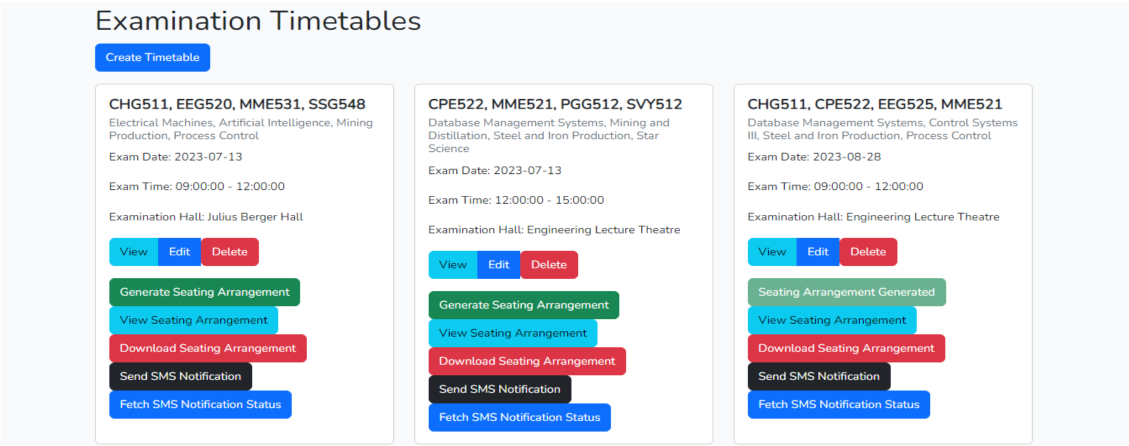

Figure 9: Examination timetable homepage

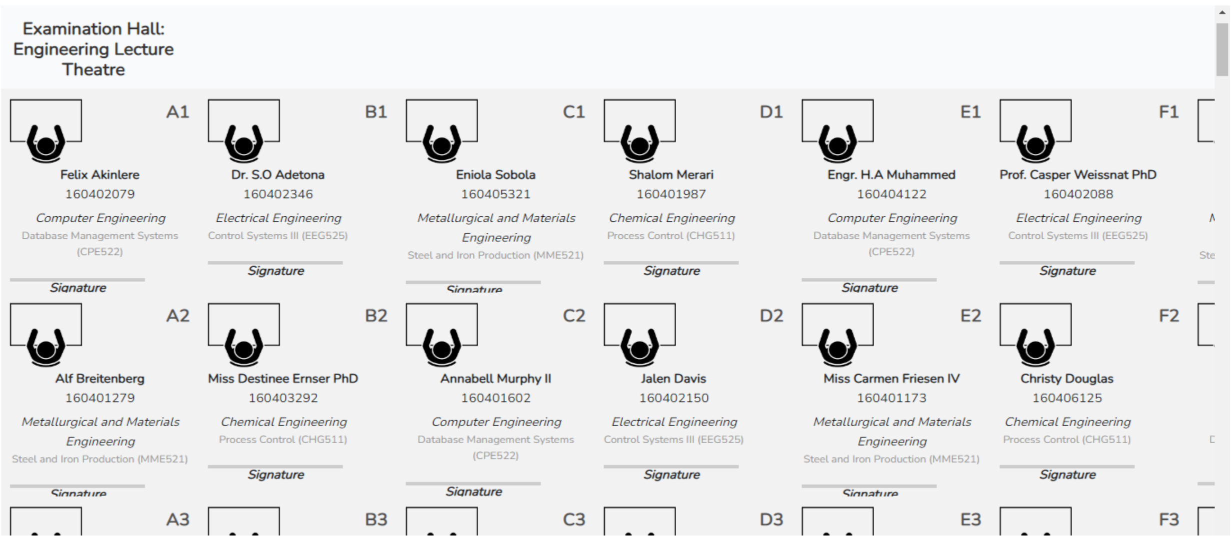

Figure 10: Graphical view and attendance for an examination hall page.

Furthermore, if a user clicks on the Register button on the home page, Figure 13 would pop-up. This page presents a 'role' selection where users can choose between 'Invigilator' or 'Admin/User' roles based on their responsibilities. For an Invigilator, he can select the 'Invigilator' role, while an Administrator would choose the 'Admin/User' role. This role selection ensures that the appropriate privileges and access rights are granted to each user, aligning with their designated roles. This important feature enhances the security and functionality of the application.

Once a registered examination invigilator opens the proposed app, he would see the homepage which is presented in Figure 4; and upon clicking on the login button, Figure 5, login page, would pop-up. Once the examination invigilator is able to login, it takes him (her) to the custom home page for the invigilator in Figure 14. The examination invigilator only has access to the examination timetable crud resource and can only access the timetable he (she) is assigned to invigilate. When the invigilator clicks on the Invigilator Timetable button, the assigned course is shown on the index page with its functionalities, as shown in Figure 15; where he(she) can view the timetable, view seating arrangement and download the seating arrangement in the PDF file.

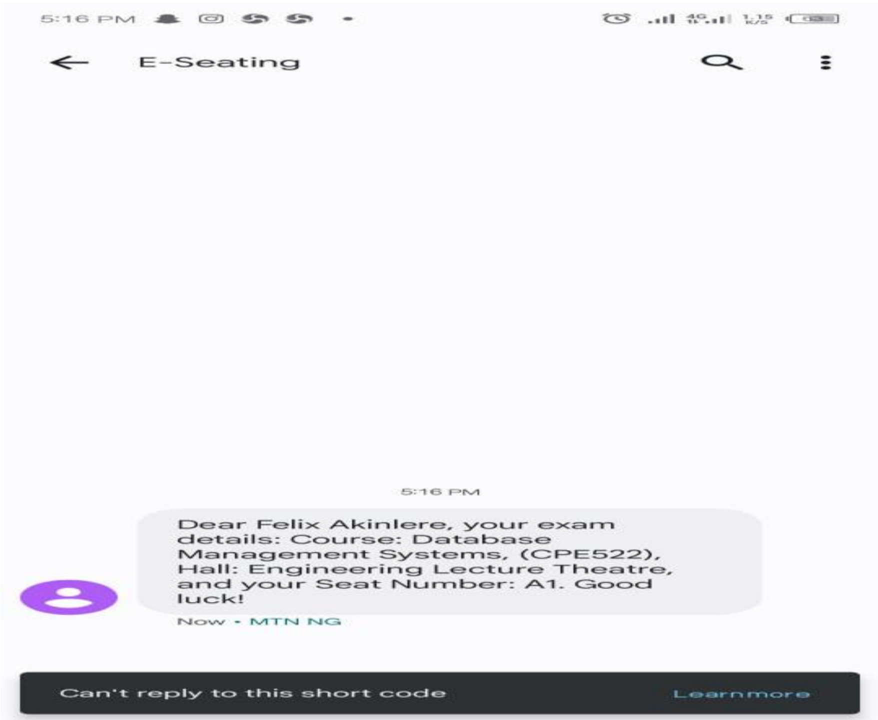

Figure 11: Text Message forwarded to student

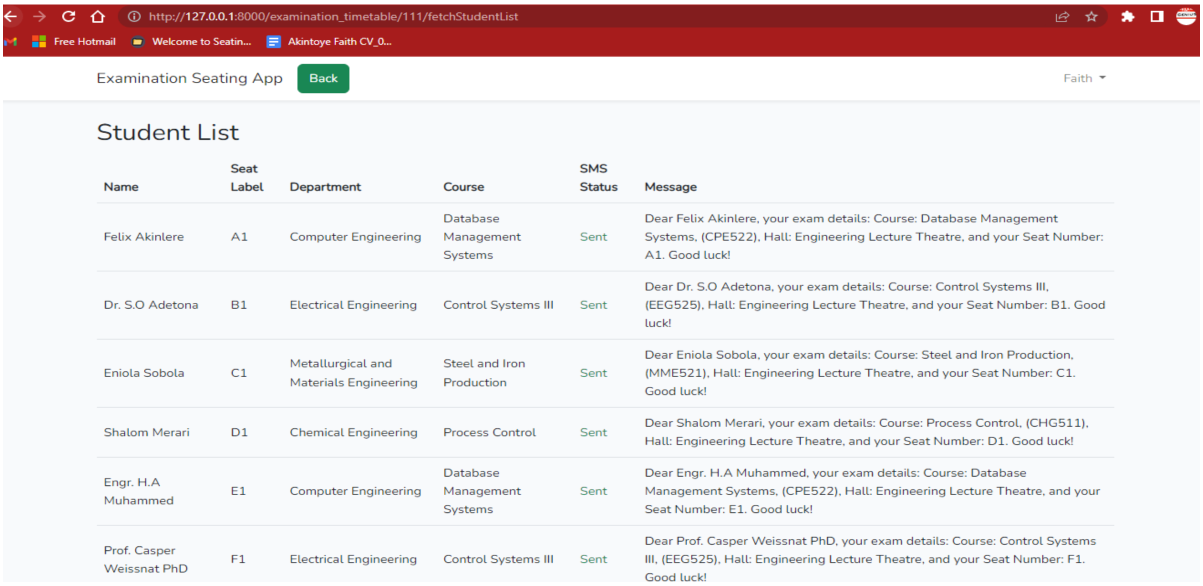

Figure 12: Status of Text Messages forwarded to the Students

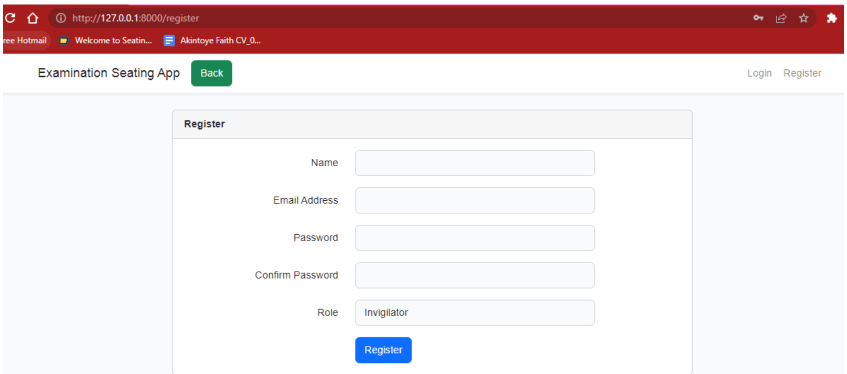

Figure 13: Registration Page

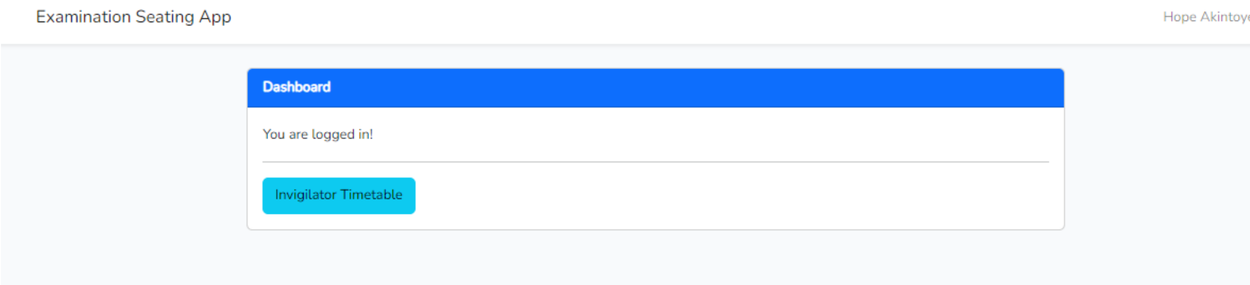

Figure 14: Invigilator homepage

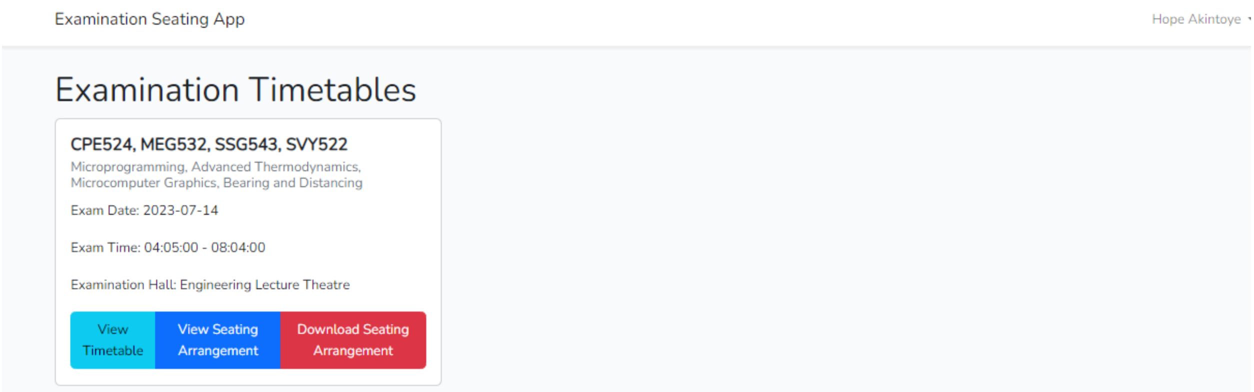

Figure 15: Examination timetable index page for invigilator

Table 11 presents a comparison of the proposed app with some existing apps for the automation of the examination seating arrangement for the purpose of ensuring that students enrolled in the same courses are not seated next to or adjacent to each other during the examination. The attributes exemplified in the table are automation of examination seating arrangement, allocation of duties to the invigilators for the purpose of the seamless examination, and assessing of the seat numbers remotely by the examinees.

It is evident from the table that the primary restraints inferred from some of the relevant apps are unavailability of the functionality that would allow examinees to retrieve their seat numbers and other vital information remotely, and lack of an appropriate facility in the existing apps that can apportion invigilators duties. All these constraints have been addressed by the proposed app reported and presented in this study.

3.2 Marketability and Adoption

The successful development of the proposed web-based examination seating arrangement app opens up possibilities for addressing a critical issue within the Nigerian educational landscape examination malpractice through "Giraffing." To determine the potential market for the proposed app, the following are considered:

a. Potential Market Segment: Our primary market includes Nigerian universities and educational institutions conducting examinations. By automating seating arrangements and implementing SMS notifications, we aim to provide a solution that ensures examination integrity and fairness.
b. Customizable for Local Needs: The proposed app addresses the prevalent issue of "Giraffing," offering a customizable solution tailored to local needs. It accommodates the specific needs of Nigerian universities,

considering factors such as examination hall sizes, course structures, and administrative workflows. This adaptability enhances its relevance and ease of integration.

c. Factors Influencing Adoption: Several factors may influence the adoption of the proposed app by educational institutions. These include its user-friendliness, the cost-effectiveness of implementation compared to traditional manual methods, and its potential to enhance examination security. The system's compatibility with existing infrastructure, such as web servers and database systems, further facilitates its adoption.

Table 11: Attributes of the examination seating arrangement app

S/N	Ref	Automation of Examination Seating Arrangement	Allocation of the Invigilator duties	Accessing the seat number remotely
1	[1]	Yes	No	No
2	[26]	Yes	No	No
3	[27]	Yes	Yes	No
4	Proposed App	Yes	Yes	Yes

4. CONCLUSION

The development of a web-based examination seating arrangement application presents a novel and effective solution to address the pervasive issue of examination malpractice and enhance the efficiency of examination management in educational institutions. By incorporating advanced graph colouring algorithms and integrating essential features such as course management, hall allocation, and timetable generation, this application offers a comprehensive and reliable platform for organizing examinations while ensuring fair and secure seating arrangements. Through the utilization of a sophisticated greedy colouring algorithm, the application intelligently assigns students to seats, taking into account course assignments and adjacency constraints. This strategic approach minimizes the potential for examination malpractice by strategically separating students who are enrolled in the same courses. By leveraging the power of graph theory, the application optimizes seating arrangements to maximize examination integrity.

Moreover, the web-based nature of the application ensures easy accessibility and convenience for administrators and invigilators. Administrators have the flexibility to manage courses, examination halls, and timetables seamlessly within the system. The application empowers administrators to create and modify timetables based on student enrolments, allocate seats efficiently, and generate comprehensive graphical representations of seating arrangements for invigilators to monitor. The inclusion of a text messaging feature, facilitated by the Termii API, allows administrators to communicate important information and updates directly to students. This serves as an additional means of ensuring transparency and reducing the likelihood of miscommunication or confusion during the examination process.

Furthermore, the application is designed with scalability and adaptability in mind, making it suitable for a wide range of educational institutions with varying needs and requirements. Its user-friendly interface and intuitive functionalities simplify the entire examination management process, streamlining administrative tasks and minimizing the potential for errors or oversights. In essence, the web-based examination seating arrangement application provides a robust, secure, and efficient solution to combat examination malpractice, promote academic integrity, and enhance the overall effectiveness of examination administration. By harnessing the power of technology and incorporating advanced algorithms, this application revolutionizes the way examinations are organized and conducted, instilling confidence in the examination process and maintaining a fair and equitable environment for all students’ paragraph text. To further enhance the proposed application, it should be adapted into a mobile application.

ACKNOWLEDGMENT

Authors hereby acknowledge the contribution of Engr. Hisham Abubakar, MUHAMMED of the Department of Electrical and Electronics Engineering, University of Lagos, Nigeria for his assistance in the cookery of this paper.

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