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Design and Evaluation of a User Centred Course-Based Timetable Scheduling System

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Abstract

In the education sector, constructing a personalized timetable is an important aspect that should be given uppermost priorities when it comes to academic planning and implementation. Basically, in most schools, the timetable is done to encompass all courses, segregation only comes in departmentally, by faculty or by programs being studied by the students involved. This could be cumbersome especially for schools with numerous programs, departments or faculties as students and faculty members have to glance through such complex timetables before they are able to map out theirs. This could lead to resource wastage in terms of time, misinterpretation by students involved, clashing of courses being taken by students, poor utilization of available venues amongst other issues. In other to proffer solutions to some of the identified problems, a personalized and user-centric timetable system was designed for the College of Basic and Applied Sciences (CBAS), Mountain Top University, Ogun State, Nigeria. System design was specified using unified modeling language (UML) diagrams such as use-case, sequence and activity diagrams. The system was implemented using mobile application development technologies. The android based timetable system presented an administrative module who could schedule lecture periods, specify time amongst other constraints and overall management of course scheduling based on courses registered for by the students. Evaluation of the system was done using Post Study System Usability Questionnaire (PSSUQ) version 3 measuring tool and analysed using descriptive statistics with SPSS version 21. One hundred and twenty five (125) participants were chosen randomly and purposefully for the study. Results of analysis gave the perceived satisfaction score as 2.56, system usefulness with 1.98, information quality with a mean score of 2.72 while interface quality performed the lowest with a mean score of 3.19 since in PSSUQ analysis, the higher the mean score, the poorer the performance. The timetable system was basically designed to reduce the problem of accessibility and better convenience especially on the part of the students. Future works would also consider a fully automated system with the use of scheduling algorithms and the integration of examination and invigilation scheduling in the same system.

Keywords: Time table scheduling, personalized systems, Android apps, Usability

1. Introduction

Generally, higher institutions of learning offer numerous courses with each having its own syllabus and various topics within a particular semester, time frame which must not collide with other activities and venues to avoid conflicts and confusion (Prashanta et al., 2020). Timetables are designed specifically to reduce or totally remove conflicts so as for some set of goals and objectives to be satisfied as ascertained by Kumar et al. (2013). In academic intuitions for instance, there are two types of timetable that is recognized which are course and the examination schedules (Herath, 2017). In cases, timetables are done in such a way that the school forms a special committee which includes at least a representative member from all departments to liaise and come up with a well synchronized and working document. However, issues such the allocation of small lecture halls for a large class, students complaint of courses clashing on the timetable, lateness in coming up with a suitable document, misinterpretation are some of the challenges posed on the traditional time tabling scheduling method which involves the use of papers and notice boards.

When creating a timetable schedule, course should be assigned to a specific timeslot for five working days of the week taking into consideration the specific classroom suitable for the respective courses and the registered number of students. For academic institutes such as universities, creating an error-free timetable is a complicated task and a lot of constraints arise when doing so (Mittal et al., 2015). Generally, scheduling of courses in many universities is prepared manually based on the level of the administrator's experience (Fadiya and Iruoma, 2015). Facilities and resources such as courses, instructors, rooms and, laboratories amongst others are some of the resources that should be considered by the administrators when creating a timetable. The manual based approach for creating a timetable could be a very exhaustive and time-consuming task (Muhammad et al., 2017).

In other to proffer solutions to some of these problems, some automated systems have currently been designed such as Kembuan et al., 2018) who designed an interactive timetable using genetic algorithm for scheduling purposes. Guo, Chen and Zhu (2011) also used greedy and genetic algorithm to solve timetable scheduling problems. Muhammad et al. (2017) designed an android based and customized timetable based on users' preferences. The inherent limitation in these systems was the fact none was designed basically for personalization which means those systems were not tailored towards meeting users' needs (Six, 2018). Hence, a fully automated and personalized timetable scheduling system was designed based on users' needs using recent technologies and its perceived user satisfaction evaluated.

2. Materials and Methods

The User Centred Design (UCD) principles was used for the design of the personalized timetable system to meet most of all the users' requirements. Users' involvement was ensured throughout the whole developmental process and it is highly iterative in nature as specified in Figure 1.

2.1 Steps in UCD

(a) Context of use specification: The users of the system are both students and lecturers of Mountain Top University

Fig. 1: UCD Process (Usability.gov, 2021)

(b) Requirements specification: Based on the highlighted constraints identified by users', the following functional requirement constraints were specified for the system.

i. No student can be assigned to more than one course at the same time
ii. A lecturer cannot teach more than one class at the same time
iii. The room should satisfy the feature required by the course.
iv. The number of students attending the course should be less than or equal to the capacity of the room.
v. No more than one course is allowed at time slot in each room.
vi. To generate the timetable based on the number of periods and time schedule.
vii. All the available courses must be entered in the timetable with flexibility for multi-period sessions
viii. Lecturers teach at their available schedule.
ix. A lunch break must be scheduled.
x. Lecturer's daily lecture hours should be restricted to be

within the allowed maximum hours.

xi. Lecturer should have normalized distributed load based on the instructor pool of subjects.

(c) System Design: System design was specified using unified modeling language (UML) diagrams such as use-case, sequence and class diagrams. The system was implemented using the combination of Hypertext Mark-Up language (HTML), Cascading Styling Sheets (CSS), Bootstrap, and React JavaScript (JS) framework for web user interface while for the Mobile interface, UIKit and Material design framework was used for IOS and Android platform respectively. For server side, Node JavaScript framework was used for connecting web and mobile interface to the database while MongoDB atlas was used for the database implementation. User interface (UI) and unit testing for the web, was carried out with Jester framework, mobile testing was done with XCTest and Junit for IOS and android respectively while the application user interface testing was carried out using Postman.

(d) System Evaluation: The usability of the system was evaluated using the PSSUQ version 3 tool designed by IBM. It is a standardized tool that has been widely used by researchers and had already been tested for its reliability and validity (Lewis, 2002). The latest version of the tool consist of 16 standard questions in which questions 1 to 6 measure system usefulness, questions 7 to 12 measure information quality and questions 13 to 16 measure interface quality (UIUXTrend, 2021). The tool operates on a Likert scale of 1 (strongly agree) to 7 (strongly disagree) and the consequence of this is that the lower the score, the better the app's performance and usability. Participants who evaluated the designed system were purposefully and randomly selected students from the department of Computer Science and Mathematics, College of Basic and Applied Sciences (CBAS), Mountain Top University, Ogun State, Nigeria. Descriptive statistics was used for the analysis of participants' responses who were chosen purposively and randomly. The students were given a list of pre-defined tasks to perform on the system, monitored and timed. They were asked to give their opinions on the app usability based on the 16 items specified in the PSSUQ. A total number of 125 students participated in the study. Table 1 gives the list of the 16 items identified in the PSSUQ measuring tool.

Table 1: PSSUQ Items (UIUXTrend, 2021)

1	Satisfied with overall system usage
2	Simple usage
3	Easy task completion
4	System comfortability
5	Easy to learn
6	Increased user productivity
7	Provision of error message to get problems solved quickly
8	Easy mistake recovery
9	clarity of information
10	Easy information retrieval
11	Relevance of information provided in task completion
12	Clear information organization
13	Interface design is liked
14	Pleasant system interface
15	System functions and capabilities
16	Overall system satisfaction

3. Results and Discussion

3.1 System Modeling

The Unified Modelling Language (UML) has become so popular amongst developers for software architecture modeling from numerous points of view (Ozkaya & Erata, 2020). The dynamic aspect of the system was depicted with the aid of the Use case diagram in figure 1. It shows the relationship and interaction between all the actors in the system which comprise of the system administrator, lecturers and students who are all the users of the system. Figure 2 and figure 3 depict the sequence and activity diagram for the timetable system.

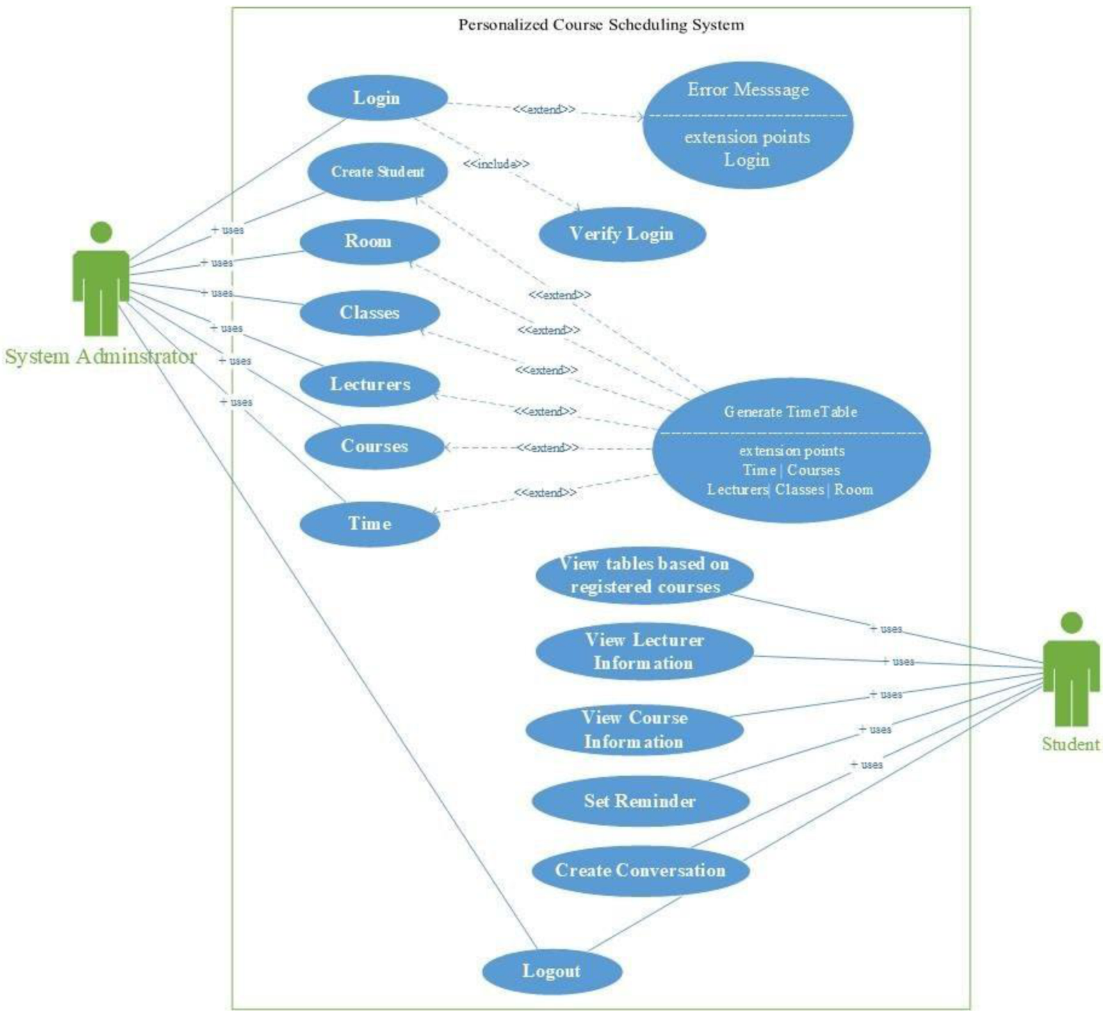

Fig. 1: Use case diagram of the proposed Timetable System

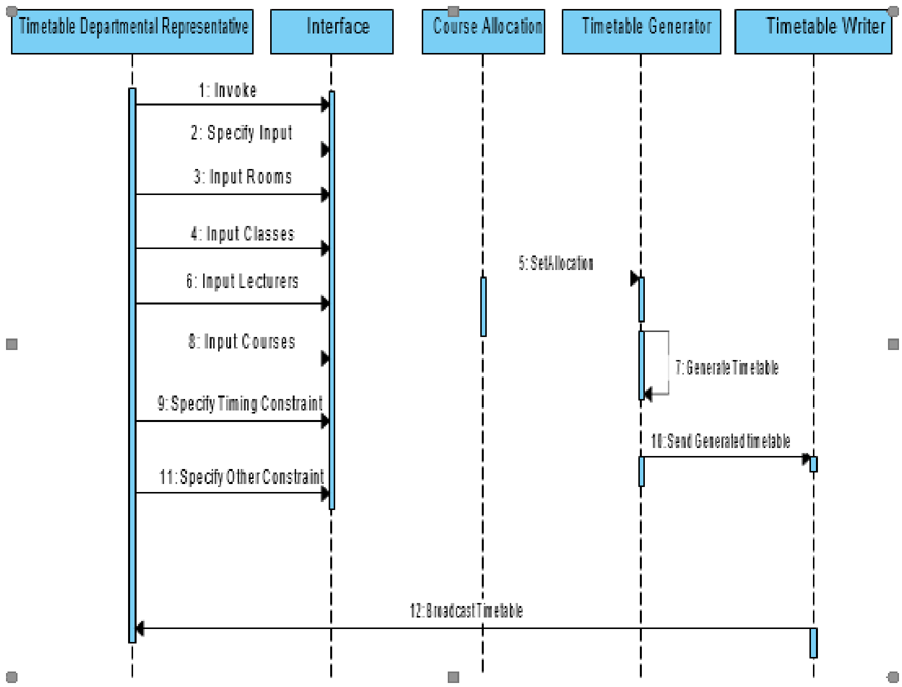

Fig. 2: Sequence diagram for the timetable system

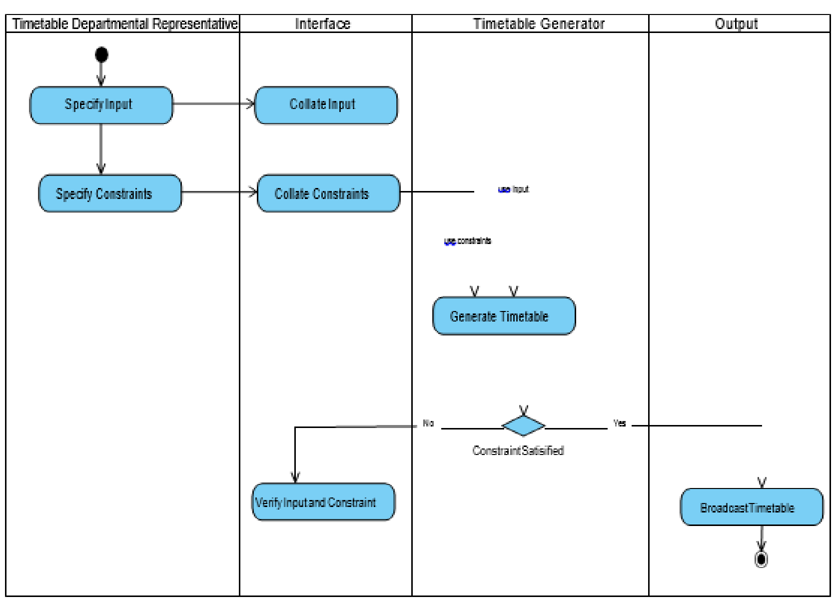

Fig. 3: Activity diagram for the timetable system

4. Results and Discussion

4.1 Timetable System Implementation

The implementation of the database named coursekit was done using JavaScript Object Notation (JSON). The database consisted of eleven database collections which were required for managing the various types of information stored and manipulated by the system as shown in figure 4.

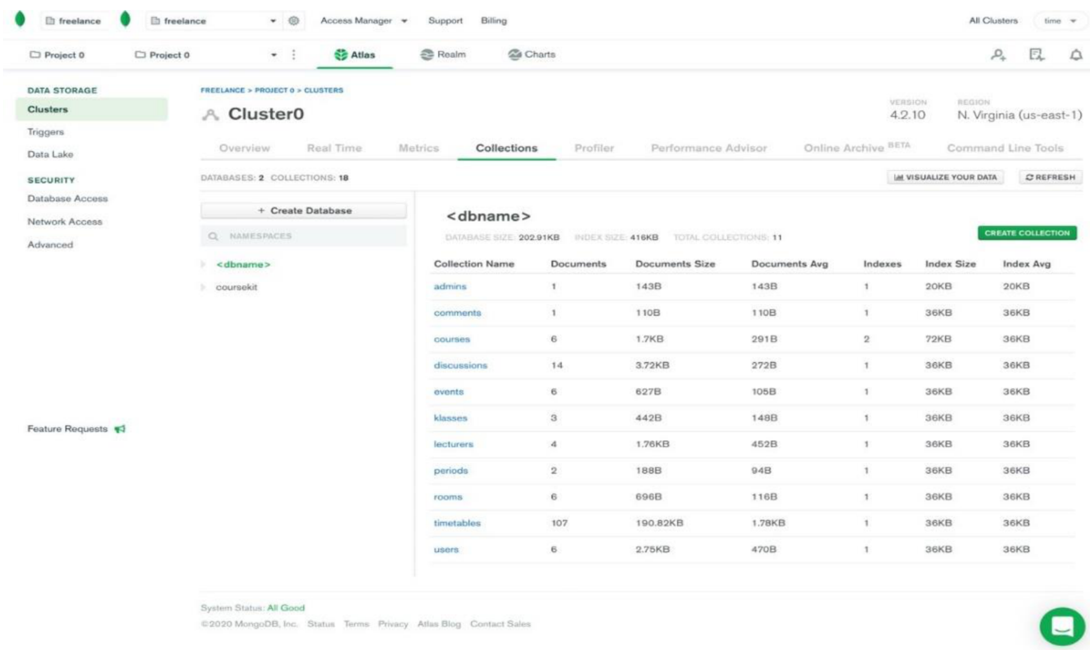

Fig. 4: Database coursekit showing its collections

Fig. 5 shows information management of courses which holds an array of documents. A document in mongoDB is a data structure composed of field and value pairs. The values of fields may include other documents, arrays and arrays of documents. A document in the courses collection had values and keys such as: _id, a unique id for each document, name, the name of the course, code, unit, description, level and color Code. Figure 6 was used to manage information about lecturers in the institution. A document in the lecturer's collection has values, and keys such as: _id, courses, name, email, educational_bg, phone_no, office_no, ranking, degree, areaOfSpec, image amongst others. Other

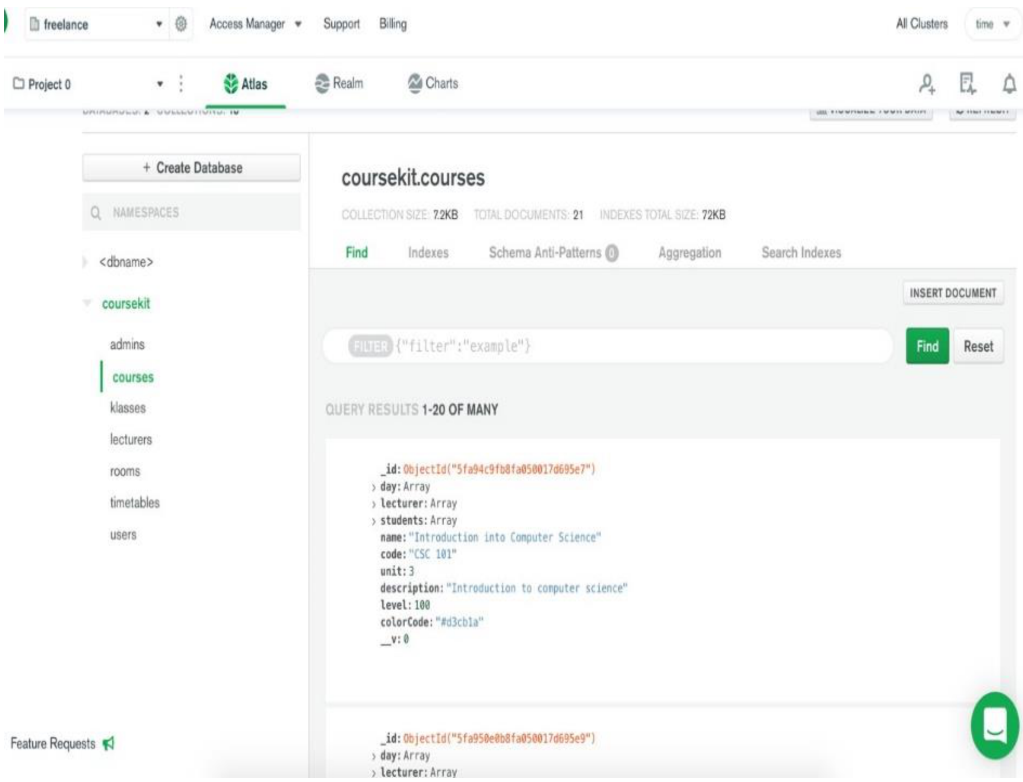

Fig. 5: Collection coursekit.courses showing the list of courses and attributes

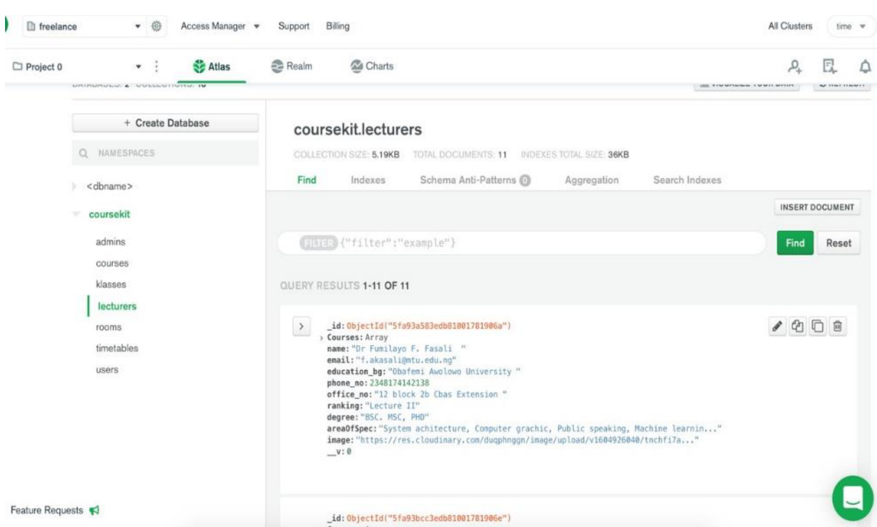

Fig. 6: Collection coursekit.lecturers showing the list of lecturer and attributes

Other collections in the coursekit include coursekit.rooms, coursekit.timetable, coursekit.users, coursekit.klasses amongst others as shown in figure 4. Figure 7 shows the system Login page also called the Home Page for departmental timetable representatives. The departmental timetable representatives are required to provide their admin number issued to them and passwords for authentication purposes.

Figure 8 shows the interface of the dashboard of the system administrator upon providing his username and password to the system. The results of this interface show the different information stored on the system so far such as number of lecture rooms, number of courses offered in a department and number of lecturers available, number of classes, number of students in a department and number of events.

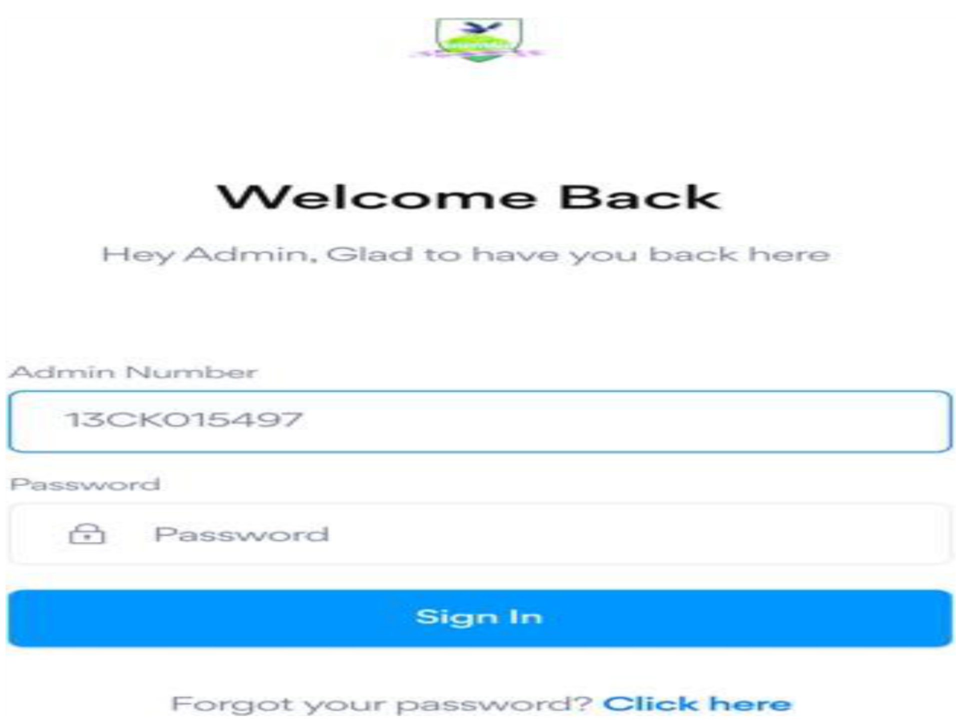

Fig. 7: Admin Login Page

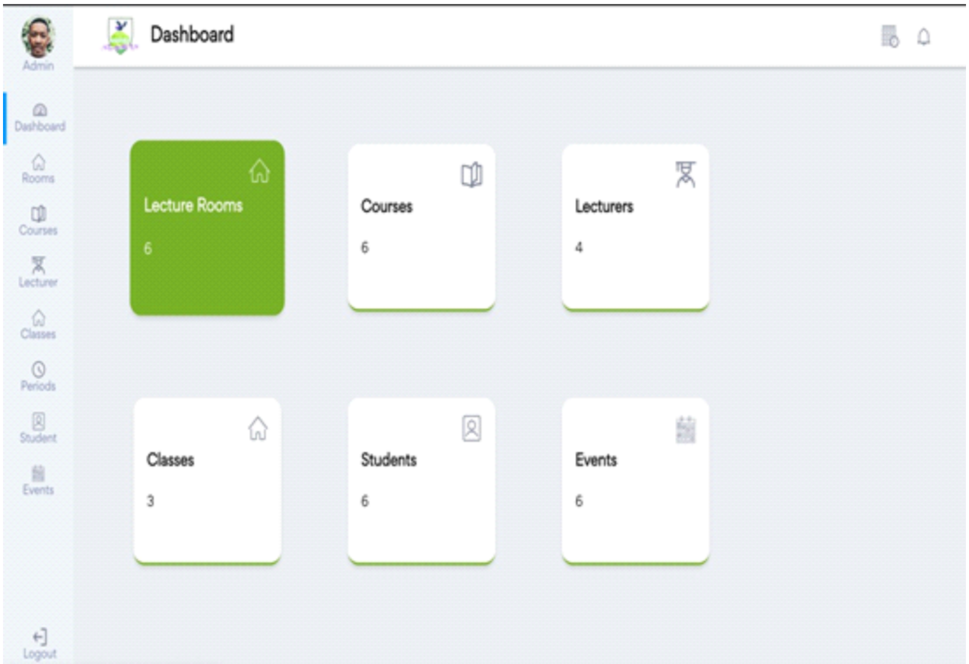

Fig. 8: Screenshot of System Admin dashboard upon login

Other admin roles include the adding of new lecturers as shown in figure 10, new courses as depicted in figure 9, creation of new classes as depicted in figure 11, add new students to the existing system as shown in figure 12. System administrators can also create a new timetable for a new semester and manage existing students amongst other roles.

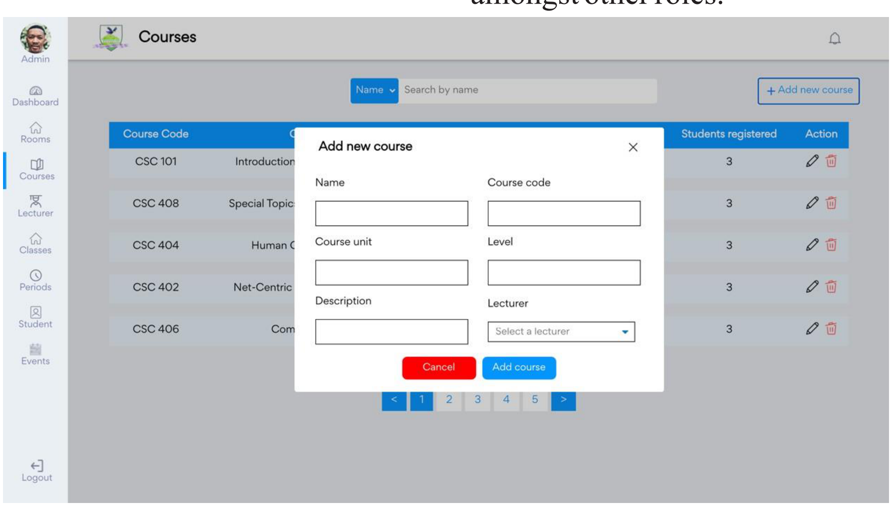

Fig. 9: Screenshot of Admin Interface for creating a new Course

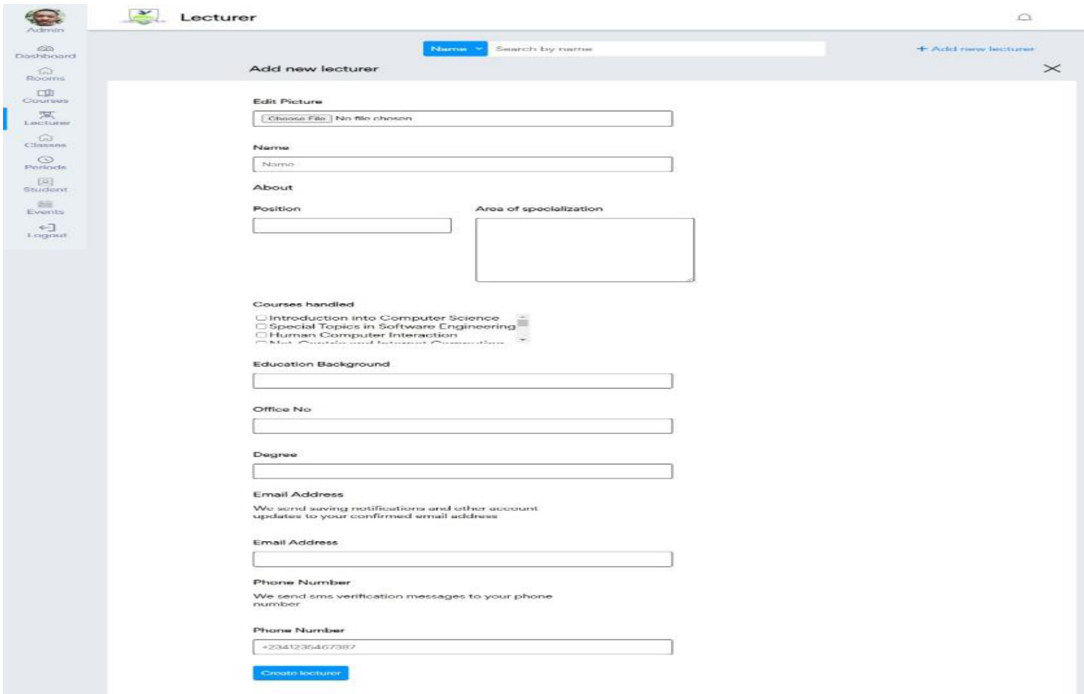

Fig. 10: Screenshot of Admin Interface for creating a new Lecturer

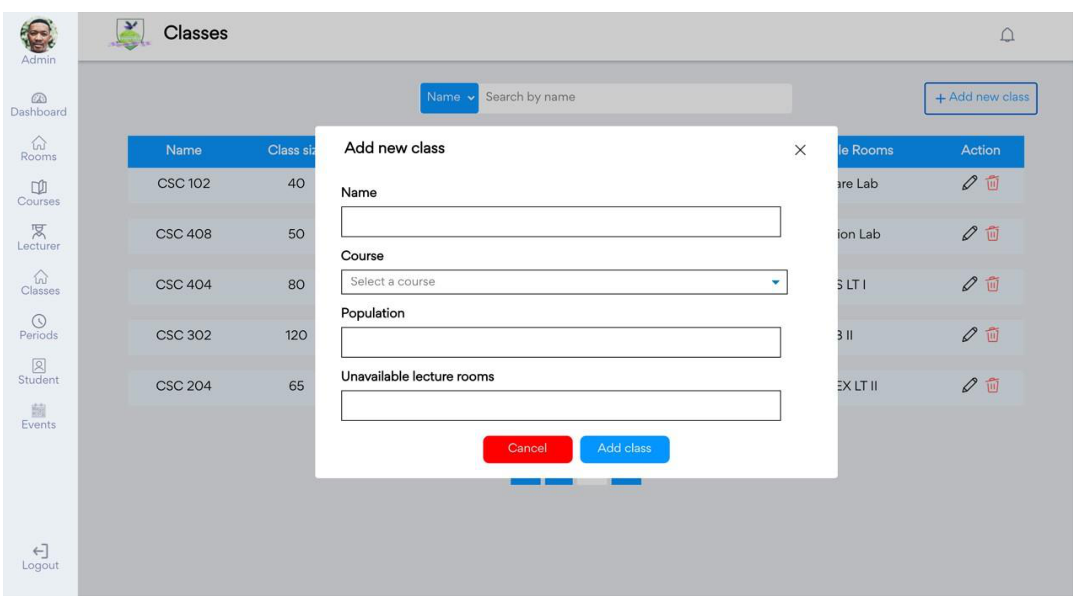

Fig. 11: Screenshot of Admin Interface for creating a new Class

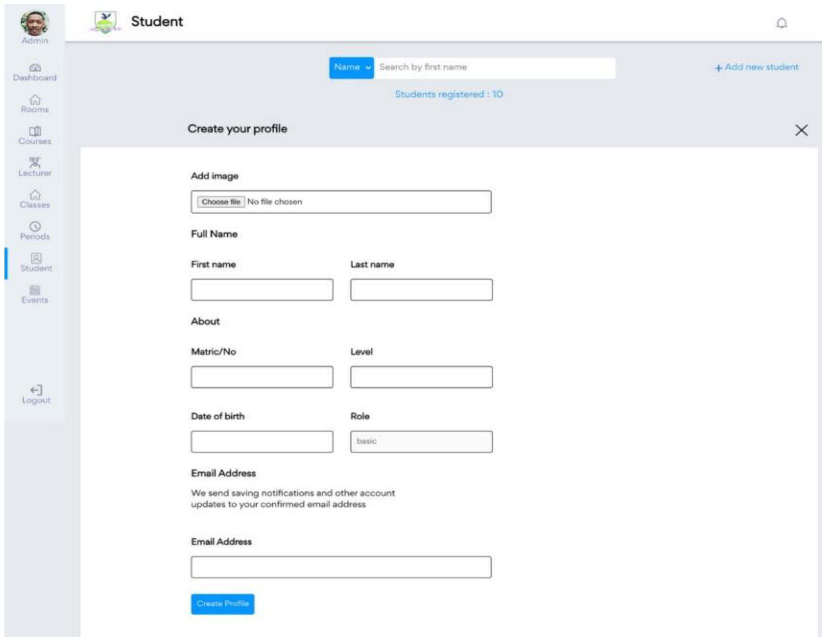

Fig. 12: Screenshot of Admin Interface for adding a new Student

Figure 13 shows the system login page also called the Home Page that gives access to students in other to use the mobile app. The students are required to provide their school mail address or school Id and passwords issued to them (their first name by default). Students can reset new passwords in a situation when they are unable to recollect their current password

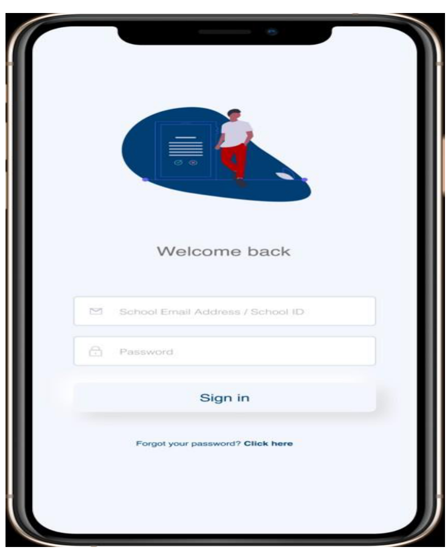

Fig. 13: Screenshot of the Login page for Student Interface

Students can register and view new courses as depicted in figure 14, add new course as shown in figure 15, edit their profile, start, view and comment on a conversation as shown in figure 15, view information about a course as shown in figure 16, set a reminder as shown in figure 17, view a lecturer handling a particular course information, view information regarding course schedules based on registered courses, view and edit their profile,

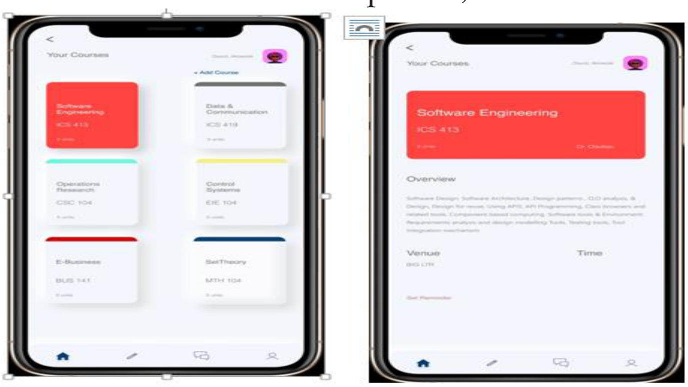

Fig. 14: Shows a Screenshot of the Respective Student interface for viewing registered courses and details of a course.

Fig. 15: Shows a Screenshot of the Respective Student interface for Adding of a Course.

Fig. 16: Shows a Screenshots of the Respective Student interface for viewing information of course schedule for a student based on registered course, and day of the week

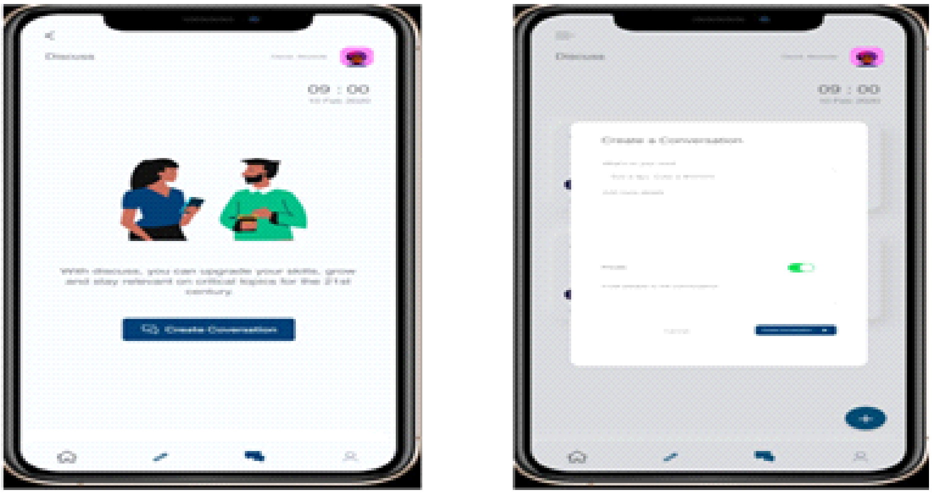

Fig. 18: Screenshot the Respective Student interface when no conversation is available and creating a conversation.

Lecturers can view the timetable once authenticated, check student profile, and make complaints to the departmental timetable representatives.

4.2 Results of Perceived Satisfaction Evaluation of the Timetable System

The results of evaluation are represented in Table 2 and this shows the result of Items for PSSUQ Analysis. Participants' responses was analysed with IBM SPSS analytics tool using descriptive statistics. Based on respondents' demographic factors, 76.8% were male while 23.2% were female, for age of respondents, 64.8% of the students ages range between 16-20years, while the remaining students were between the ages of 21 and 24 years old. For respondents' level of study, 36% were in 200 level, 44.8% were in 300 level while 19.2% were in 400 level. This is because in MTU, the 300 level currently boast of the highest number of students followed by 200 level. 100 level students were not used for this study since they were still going through the admission process as at when this study was done.

Table 2: Result of Items for PSSUQ Analysis

Items	Mean Value	Standard Deviation	Interpretation
1	1.74	0.812	The participants fairly agreed that they were satisfied with how easy it was to use the app
2	1.86	1.011	The participants fairly agreed that they were satisfied with how simple it was to use the app
3	1.94	1.120	The participants fairly agreed that they were able to complete the tasks and scenarios they were given quickly on the app
4	2.26	1.482	The participants fairly agreed that they felt comfortable using the app
5	2.01	1.208	The participants agreed that the mobile app was easy to learn
6	2.06	1.266	The participants fairly agreed that they believe they would become more punctual, organized and committed to lecture periods with the use of the app.
7	4.85	1.592	The participants disagreed that the app gave error messages that clearly told them how to fix problems.
8	2.43	1.603	The participants fairly agreed that whenever they made a mistake using the app, It was easy and fast for them to recover.
9	2.44	1.547	The participants fairly agreed that the information (such as online help, on -screen messages, and other documentation) provided within the app was clear.
10	2.22	1.329	The participants fairly agreed that it was easy to find the information they needed on the app
11	2.26	1.421	The participants fairly agreed that the information embedded in the app was effective in helping them complete the tasks and scenarios given.
12	2.13	1.374	The participants fairly agreed that the organization of information on the timetable scheduling app interfaces was clear
13	2.24	1.578	The participants fairly agreed that the interface of the app was pleasant but should be improved on during subsequent design.
14	2.51	1.639	The participants agreed that they liked using the app interface.
15	4.14	1.795	The participants neither agreed nor disagreed that the app has all the functions and capabilities they were expecting.
16	3.90	1.696	The participants neither agreed nor disagreed that overall, they were satisfied with this system
Upper Limit	4.85	-	
Lower Limit	1.74	-	

From Table 2, it was realized that the overall perceived satisfaction of the designed personalized timetable app was 2.56 which indicates that most of the participants agreed to being satisfied with the app's usability. The system usefulness gave a score of 1.98 meaning that the students fairly believed that the developed app would be very useful to smooth running of academic activities in the college. The result of information quality analysis yielded a mean score of 2.72 which indicates that most of the students that participated in the study also agreed that the quality of information embedded in the app is satisfactory but can be subjected to further improvements and lastly they also felt that quality of the interface is okay since result of that analysis gave a score of 3.19.

Item 1 had the best rating with a mean value of 1.74 which means most of the students believed were satisfied with how easy it was to use the app. Item 7 (provision of error message) and Item 15 (system functions and capabilities) performed poorest with mean values of 4.85 and 4.14 respectively. This came as no surprise since (Sauro and Lewis, 2016) already affirmed that ever since PSSUQ was developed, Item 7 had always received the poorest ratings from usability researchers. As a result, during further design or upgrading, the items with the highest mean scores would be focused on for better improvement and higher usability.

5. Conclusion

This paper discussed the design, implementation and evaluation of a personalized timetable app using recent mobile app design technologies. A user centered system was designed with the aid of UML diagrams and implemented with MongoDB, Bootstrap, React JS amongst other current mobile development tools. The usability of the system was ascertained with the use of the PSSUQ measuring tool using a total of 125 students who were randomly and purposively selected Results of evaluation indicated that most of the students agreed to being satisfied with the apps' usability although suggestions for improvements were made which are subject to further study and prototype design. The designed app has the tendency to improve the flexibility of a traditional timetable construction, productivity as well as improve vast academic practices. The system would drastically minimize the time and resources expended on schedules, thereby allowing the departmental timetable representative more time to focus on other pressing matters of the institution which in return will lead to greater productivity. This study is limited to the development of automated timetable scheduling for scheduling of courses for departments in a university. The system is limited to the departmental timetable representatives and students.

6. Recommendations

In developing an effective personalized timetable for academic institutions, the complexity and numerous constraints that need to be considered cannot be overemphasized. Subsequently, usability is an important construct to be considered as it could determine the success or failure of apps in the software development industry. Based on the result of this study, the following are recommended

- Adoption of the use of a fully automated process through the use of genetic algorithms or any other effective process for course scheduling
- The mobile app could be enlarged to accommodate all university wide courses, examination

timetable scheduling, mid semester assessment timetable and invigilation roasters.

- Future works can also be focused on a comparative analysis of the usability of other existing timetable scheduling systems.
- For evaluation purposes, a wider range of users which would include both students and faculty members would be considered.

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