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# University of Kufa unified laboratories management system using computer application

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**ABSTRACT**

The laboratory organization is essential in the university to maximize system convenience, accuracy, appropriateness, and sustainability. The laboratory data system is an information supplier that aids in arranging data sources and decision-making processes. In this work, unified laboratories management system (ULMS) was presented in the educational field for managing and scheduling lab equipment information. There are two steps in the research process: the first is to examine the old approach for organizing and scheduling laboratory equipment and suggest a better one. The approach adopted in this system is the first-come first-served rule governs task priority (FCFS). The second step is creating a computerized system for scheduling and managing laboratory equipment. For programming, C# and structured query language (SQL) are used. This system's design included user and administrative integration (manager, technicians, and researchers). An information application system plan was created because of this research to manage the scheduling information for lab equipment. As a result, it can help the management of the laboratory describe all operational tasks in a way that is considerably simpler and produces outcomes more quickly and accurately.



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## 1. INTRODUCTION

Organizational labs serve critical functions, including research testing and educational responsibilities [1]. According to Pandermarakis *et al*. [2], the role of a laboratory can include simple learning and exercise, feature control, reverse engineering, and pure technical evaluation. Engineering education laboratories can be classified into three different types: active with tools that are real, virtual or simulated, and dispersed or remote education [3]. The laboratory activity aims to advance practical and experimental services, knowledge, and skill by direct interaction with genuine phenomena and materials, equipment, and tool. The laboratory, in order, has a variety of tools, machines, and other equipment. Therefore, setting up the kit is critical to making laboratory activities productive and efficient [4], [5]. Typically, Microsoft Excel was employed in the lab as a classic piece to record laboratory equipment information. However, this might make tracking the data report complex, time-consuming, and subject to human error. Therefore, a computerized management system is required to record, manage and schedule the laboratory equipment. This system should balance safety and efficiency to allow lab employees to work while protecting themselves and the environment. Rui [6] and Chen *et al.* [7] recently the laboratory accidents have seen a rise in the number at both domestic and international institutions, with the proportion of explosive incidents reaching 29%. To achieve this purpose, a centralized system and its databases must gather and use entirely research content, laboratory workers, experimental materials, and experimental equipment [8], [9].

A strategy for achieving the goal of the laboratory as effectively as possible through planning, organizing, using, and regulating all laboratory revenues is known as laboratory management. It's critical to ensure that laboratory management revenues attract higher education, organizational administrators, and certification forms [10]. Managers, researchers, lab supporters, engineers, and laboratory services like tools, space, and equipment can make money from teaching in the lab. The goal of the laboratory management system is to manage the instruments and materials used in the lab for routine exercises, machine conditions, state material lists, and practice maintenance. The performance of the laboratory management system may be increased by computerized development [11].

WebLab-Deusto is an open-source remote laboratory management system (RLMS) that allows remote laboratories to be constructed, maintained, and shared with other universities [12]. According to Garcia-Zubia *et al*. [13], the WebLab-Deusto architecture provides the controlled method at the lab level, which isolates the software created by the distant lab developer in a local network at the university level. The WebLab-Deusto team argued that the laboratories only require a web browser, and the team has contributed to the HTML5 adoption of other remote laboratories. As a result, any issues with firewalls and proxies are eliminated, and it can operate on any web browser (even on mobile phones) [14].

According to Baldea and Harjunkoski [15], the goals of scheduling actions include enhancing resource utilization, decreasing waiting times, reducing records or the number of tasks waiting in line, and assisting with capacity planning decisions. The first-come first-served (FCFS) rule, shortest processing time (SPT) rule, shortest total processing time remaining (STPTR) rule, earliest due date (EDD) rule, and fewest operation (FO) rule are some essential scheduling rules. The scheduling of activities in the laboratory included: operating machinery or equipment, doing a task or working sheet of practice, obtaining machinery or equipment, ordering a practicum for materials, and maintaining equipment or machinery [16]. For managers, researchers, laboratory supporters, engineers, and the person in charge of laboratory management, it might be challenging to support preparation-based information technology for laboratory equipment. A solid and accurate schedule is a foundation for effective and efficient laboratory activity or working use. This study aims to build and develop a system planning information technology built for laboratory equipment.

## 2. BACKGROUND

The arrangement determines the process schedule, including the distribution of resources, equipment, labor, and process implementation sequence. To reduce the processing and waiting times; use resources such as space, humans and equipment efficiently, arrangements should be made in the laboratory's education. According to Gupta and Sivakumar [17] the priority rules were suggested as a method for scheduling due to execution and the least time of difficulties.

The system is a combination of humans and machines used to assist in information processing tasks. According to Sousa and Oz [18], a method is a connected network of elements assembled to carry out an activity or accomplish a specific objective. The system uses computer hardware, software, decision-making processes, and databases. To support management decision-making, Hasan *et al*. [19] define a system for managing information as a computer information-based system that collects all data from internal systems as management-oriented record keeping.

Additionally, a system that manages information is a group of hardware, protocols, software, documents, forms, and personnel working together to process and distribute data that is valuable for management. The term "laboratory information system" refers to the system that controls and maintains the information from the laboratory. This information system includes all activities in the laboratory, such as equipment availability, users of un equipment, input and output data from the laboratory, data archiving and management. All laboratory equipment must have documentation for all equipment acts, including thorough records, documentation, and arrangement [20]. The system of laboratory information has the following benefits [12]: firstly, providing the ability for managers and users to submit the data to the server in an easier way than using manually entering data, and secondly, it is connected to other laboratory information activities such as archiving, searching of data, and readily examined by managing the laboratory.

According to Pressman [21], the system design process has three phases: the design procedure, database design, and user interface design. In addition, relationships and characteristics between entities are described at the stage of database building. A database is a set of related data that provides an overview of the data and is designed to fit an organization's information requirements [21]. The data stored in the database is maintained in a consolidated manner. Database management system (DBMS) is a software application that allows users to describe, construct, support, and switch access to the database [22]. The DBMS will enable it to create and update files, choose and organize data, and produce reports.

Also, Pressman [21] stated that the waterfall model is a software design and development method. As seen in Figure 1, this model comprises a series of linearly sequential activities that go from one level to the next; it starts with defining the requirements and ends by maintaining the operation. On the other hand, Figure 2 shows the incremental model [23] as another method where the software development life cycle's requirements have been broken up into several independent parts. The first stage should immediately proceed with subsequent steps in the total procedure model.

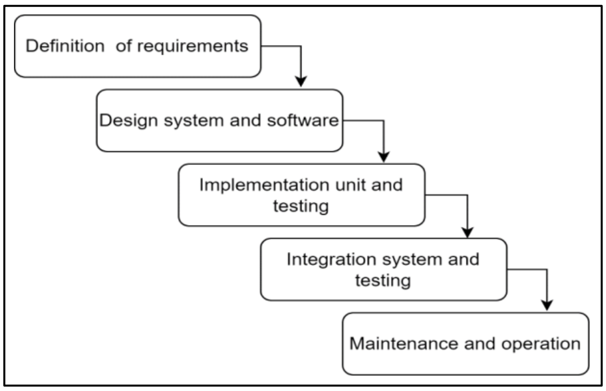


Figure 1. A development waterfall model for the information system design [21]

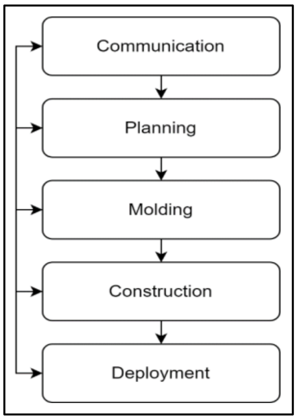


Figure 2. The development incremental model for the information system design [23]

## 3. METHOD

The study uses a technique that combines modeling and inquiry, such as material or data research, design techniques, analysis, implementation, and inspection of software applications. This project was presented as a laboratory case study at Kufa, an Iraqi university. A flowchart of the steps that contributed to the creation of the unified labs system design is shown in Figure 3. The process starts with gathering the following information: name, device age, and need for repair. The study and design of the data processing infrastructure for the laboratory data arrangement adopted an incremental model development. The model requires a systematic and structured way to develop software applications, starting from the system planning, design and analysis stages. Since Kufa laboratories use a dynamic scheduling method, FCFS process standards have been adopted.

The software application of the unified labs system was designed using the following specifications: Windows 10 operating system, Intel Core i3 processor, 4 GB of RAM, C# programming language, and structured query language (SQL) database. In the proposed system, the data are stored within the servers of the University of Kufa. A wireless network is used to communicate between the devices associated with the system and the databases. It enables its workers and researchers to quickly access this data according to their needs and different access permissions. The program has been adapted to work on other operating systems without changing computer hardware or software.

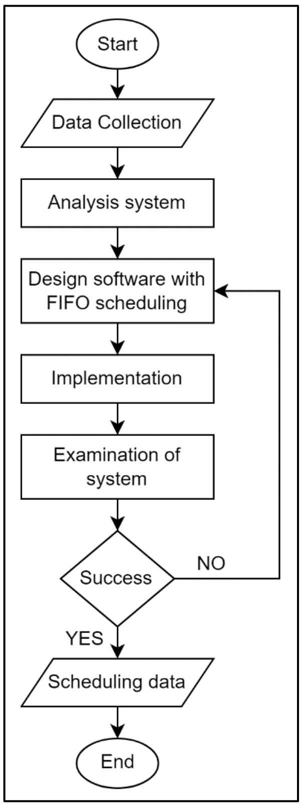


Figure 3. Flowchart of development unified labs system

## 4. IMPLEMENTATION

### 4.1. Programming language and database design and structure

C# represents the high-level programming language for the Microsoft.NET platform. It shares many traits with other languages and is considered the language chosen for this type of study and is expected to be widely used. Construction is a crucial focus for language research [24]. This study introduces a brand-new C# program created to supply that infrastructure.

The programming language mainly used to enter information data in the systems' database is SQL. SQL was initially used with relational database management systems (RDBMS) [25], but as different categories in the database system have emerged, its use has been consciously extended. SQL was developed to be a potent query language in widely accessible and highly dispersed systems that analyze big data. Figure 4 displays all database tables of the proposed approach and their relationships. Based on the gathered requirements, we organized the information into five tables: devices, users, used devices, labs, and colleges and departments.

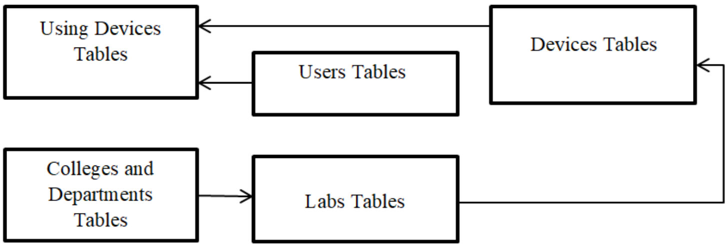


Figure 4. The database structure and relations

### 4.2. System administration with user's privileges and rules

The system administrators provide the users with the appropriate permission, which gives a great scope in controlling the process of adding data and making continuous updates on the information by the persons assigned to manage those laboratories. According to the available permissions, each worker in the laboratory can perform their tasks efficiently; also, the researchers wishing to obtain information of interest to them in the field of their scientific research can access the system and check the available equipment. The system administrators provide the users with the appropriate permission, which gives a great scope in controlling the process of adding data and making continuous updates on the information by the persons assigned to manage those laboratories. According to the available permissions, each worker in the laboratory can perform their tasks efficiently; also, the researchers wishing to obtain information of interest to them in the field of their scientific research can access the system and check the available equipment. All the system permissions are listed, with an explanation of the capabilities of each of them. Table 1 shows the available rules and permissions and who is the responsible for its performance:

- Admin: this account is intended for the person responsible for managing the accounts of all users, providing technical support for the unified laboratory system and technical handling errors if they occur in the program and databases.
- College: the owner of this account is responsible for managing user accounts within his college, following up on data entry into the program by the rest of the colleges' employees, and checking updates on the data on an ongoing basis.
- Department: this account is given to those in charge of laboratories in the scientific department, where the authorized person manages the data entry of the laboratory into the system and continuous updates on laboratory equipment information.
- Reader: this account is granted to scientific researchers wishing to obtain information about scientific laboratories and their equipment to use them for scientific research and its requirements.

Table 1. Different user’s permissions and rules

| Rules | Admin | College | Department | Reader |
|---|---|---|---|---|
| Register employee | ✓ | ✗ | ✗ | ✗ |
| Add equipement | ✓ | ✓ | ✓ | ✗ |
| Add labritory | ✓ | ✗ | ✗ | ✗ |
| Update equipment | ✓ | ✓ | ✗ | ✗ |
| View equipment | ✓ | ✓ | ✓ | ✓ |

## 5. RESULTS AND DISCUSSION

This research created a method for recording the current equipment of laboratories in the University of Kufa as a case in this study, as well as a scheduling arrangement of laboratories equipment of based information system. A conventional system is based on efficient equipment management in the case study labs. As a result, it demonstrated a drawn-out process, the possibility of human error, and the loss of equipment or its damage or unusability. The rebuilt and financed equipment only records data into a Microsoft Excel sheet. Additionally, there needs to be a coordinated scheduling system, which results in a lack of control over the lab equipment. As a result, managing occurrences involving laboratory equipment data information was challenging for managers, researchers, and laboratory management. Therefore, the outdated system could be more practical and optimal.

In this project, a unified laboratories management system (ULMS), a developed system's computer-based application for scheduling lab equipment, was created. Sub-data system and subsystem discussion comprise an analysis of the developed system. The system's sub-data was a software-managed database that contained information relevant to the state. Entity relational diagrams (ERDs) were used to define database development and serve as a guide for database architecture.

New system offers flexibility in equipment scheduling, process equipment derived, and return rental equipment. This innovative technique had the advantages of reducing errors and ensuring accurate recording. The FCFS method defined task priorities in advance for scheduling lab equipment. It was considered that organizing tasks by the date that came from a predetermined task to be prepared. Figure 5 shows the system's main menu; it includes the operation of adding, editing, and viewing equipment, laboratory, and user accounts. The menu considers the activities based on the user account rules and permissions. All users can view the equipment and filter the results based on their needs; Figure 6 shows the different filters, such as university, college, department, and laboratory. After viewing the results, the user can print the report or export an Excel version.


Figure 5. Main menu of develop unified labs system

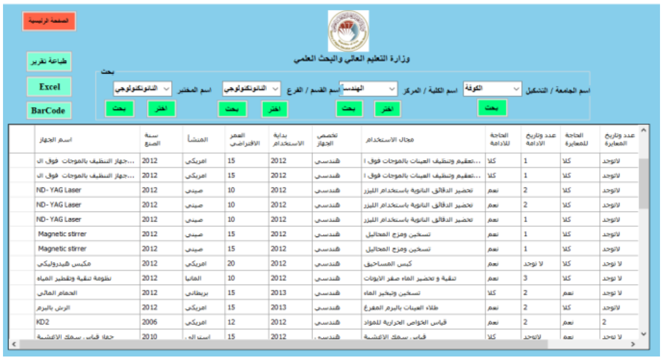


Figure 6. Sample report of scheduling unified labs system

## 6. CONCLUSION

The computerized approach to operating lab equipment is beneficial in learning and teaching. It also makes it simpler to obtain information on equipment availability and scheduling. This project aims to create a system for scheduling information technology based on lab equipment. The FCFS dynamic scheduling was employed to establish the order of importance for making decisions. The software was created using C# and SQL as the programming language and database. The situation study was overseen in the laboratories of the University of Kufa-Iraq. An optimum performance of the Kufa ULMS was obtained after examining the resulting application. Using this developed system, we get a more efficient, speedier, and more accurate piece of equipment for data handling.

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