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جامعة الملك سعود
King Saud University
كلية علوم الحاسب والمعلومات
قسم تقنية المعلومات

Elmam - إلمام

IT 497: Graduation Project Report
Product Release-2

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Elmam - إلمـام

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In response to the complex challenges of managing public buildings, particularly in the efficient use of space, safety, and environmental conditions, our Elmam system addresses the critical necessity for a comprehensive smart building monitoring system. Focusing on the growing trend of IoT technologies in smart buildings, we present a unique solution tailored to the specific needs of building managers in educational institutions. Our approach integrates hardware and software components, such as temperature, air quality, and noise sensors, connected to microprocessors to provide real-time monitoring, enabling proactive environmental issue resolution, space optimization, and improved productivity and well-being for occupants. In addition to these features, Elmam provides an easy-to-use interface for managing room availability, generating weekly reports, and an interactive map displaying air quality and temperature data. Beyond its local impact, our system contributes to Saudi Arabia's Vision 2023 by promoting environmental sustainability through efficient space utilization and improving indoor environmental conditions. The implementation of the Elmam system at the College of Computer and Information Sciences at King Saud University has enhanced the detection of internal environmental standards for buildings. This implementation has enabled us to create a suitable and comfortable environment for students within the halls, contributing to increased productivity.

يواجه مديري المباني تحديات معقدة في إدارة المباني العامة، خاصة فيما يتعلق بتحسين استخدام المساحات بكفاءة، وضمان السلامة، وتوفير ظروف بيئية ملائمة. يأتي نظام إلمـام كحل لهذه التحديات، حيث نسعى إلى إقامة نظام شامل لمراقبة المباني العامة. مع التركيز المتزايد على تقنيات إنترنت الأشياء في المباني، نقدم حلاً فريداً مصمماً خصيصاً لتلبية احتياجات مديري المباني في المباني العامة. من خلال مستشعرات لقياس درجة الحرارة، وجودة الهواء، ومستويات الضوضاء، متصلة بمعالج صغير مما يمكن من حل المشاكل البيئية بشكل فعّال، وتحسين استخدام المساحة، وبالتالي تعزيز الإنتاجية ورفاهية مستخدمي المبنى. إضافة إلى ذلك، يوفر إلمـام واجهة سهلة الاستخدام لإدارة توافر الغرف، وإنشاء تقارير أسبوعية، و خريطة تفاعلية تعرض جودة الهواء ودرجة الحرارة. وخارج النطاق المحلي، يساهم نظامنا في رؤية المملكة العربية السعودية 2023 من خلال تعزيز الاستدامة البيئية عن طريق الاستخدام الفعال للمساحات وتحسين ظروف البيئة الداخلية. حيث أظهر تطبيق نظام إلمـام في كلية علوم الحاسب والمعلومات في جامعة الملك سعود مراقبة حية و فعالة للبيئة الداخلية لغرف المبنى مما يحسن في الكشف عن معايير البيئية الداخلية بشكل مباشر لتوفير بيئة مناسبة ومريحة للطلاب داخل القاعات، والذي يساهم في زيادة الإنتاجية.

Keywords: smart building monitoring, IoT technologies, environmental conditions, space utilization, building management, sensor integration, real-time monitoring, sustainability.

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1 Introduction

Nowadays, with the abundance and rapid expansion of public buildings, managing them is a challenging task in terms of: assessing building spaces quality and utilizing these spaces effectively. To optimize building conditions we need to enable smart buildings that use IoT technologies which offer continuous monitoring.

Moreover , many smart buildings (ex: Honeywell)[1] that use IoT technologies and sensors for continuous monitoring are essential for managing public buildings efficiently and optimizing building conditions. These sensor-based systems provide valuable insights into the indoor environment, allowing building managers to make informed decisions and take timely interventions to improve energy consumption, occupant comfort, and overall building functionality.

Figure 1.1 Honeywell building monitoring system

This introduction includes a brief description of the project, the problem, the solution and the product vision. The methodology that was used, and the main contribution.

1.1 Problem

Since people spend approximately 90% of their time indoors [2], building monitoring has become a concern for managers of public buildings, such as colleges and schools. Users of these buildings require a safe and comfortable environment for their activities. In return, efficient utilization of public buildings, compliance with safety and sustainability standards, and optimization of space usage are crucial. The productivity of individuals within these structures can be notably affected by inadequate lighting and air quality. Our project aims to address several challenges faced by building managers, who are constantly seeking ways to maximize the use of spaces, such as classrooms, halls, and laboratories, while ensuring a safe and conducive environment for faculty and students. Building managers also grapple with difficulties in efficiently organizing lecture halls, especially when transitioning to online lectures or canceling in-person classes. As a result, rooms may become available, but their schedules may not accurately reflect their availability. Moreover, monitoring multiple halls presents a significant challenge to building managers, as they must ensure the safety of the internal environment for each space.

1.2 Solution

Our objective is to develop a comprehensive building monitoring solution, integrating both software and hardware components. The smart building monitoring system we propose employs multiple sensors to oversee critical factors like air quality, temperature, and noise levels. Through the incorporation of an air quality sensor, we aim to create and maintain a high-quality indoor environment that promotes comfort and well-being. Similarly, temperature sensors play a crucial role in ensuring the comfort of building occupants, allowing us to monitor and regulate temperatures across various classrooms and laboratories. The impact of room location and exposure to sunlight on overall temperature within the building is a key consideration. Additionally, noise sensors enable effective monitoring of sound levels in all classrooms and labs, addressing the specific concerns of building managers in the Public Buildings Department.

To address the challenges faced by building managers, particularly in the monitoring of indoor environments and optimization of space, our approach involves designing sensor-equipped boxes placed in multiple classrooms. These boxes are connected to microprocessors that transmit raw sensor data through the Internet of Things Messaging Protocol, facilitating the collection of intelligently processed, real-time data on the building's interior environment. This technological advancement empowers building managers to efficiently oversee multiple facilities, ensuring safety, productivity, and operational efficiency. The Elmam system provides a user-friendly interface for building managers to register, log in and out, view room availability, and access weekly reports on building statistics. It also offers a detailed map displaying air quality and temperature data for specific rooms at specific times, issuing alerts in case of potential issues. While building managers can monitor sensor data and access front-facing information, they are restricted from editing profiles, adding or modifying sensors, and altering weekly reports. Elmam employs various programming languages, including HTML, CSS, JavaScript, PHP, and JSON, along with devices such as the DHT11 temperature/humidity sensor, MQ-2 air quality sensor, and noise sensor, all programmed using C++. An Arduino (ESP12) serves as the microprocessor, collecting and storing environmental data in our database.

1.3 Product Vision

For Building managers/Decision makers.
Who want to effectively manage buildings remotely through a single interface to be able to utilize spaces and ensure quality in the building (such as air quality).
The **Elmam إلمام** is a complete system that includes a website.
That monitors the building without violating people's privacy.
Unlike other Building Management System (BMS) (Mouwasat hospital system) [3] and (jsaas-safety.com) [4].
Our product ensures that the privacy of people in the building is not violated by using privacy-preserving sensors (such as noise sensors) and targets colleges/schools buildings with suitable/valuable features such as ensuring space utilization.

1.4 Methodology and Steps

Our approach to building a smart building monitoring system includes several key steps and methodologies, which collectively constitute our unique solution for addressing the challenges faced by building managers. Initially, we conducted experiments to test the effectiveness of the three sensors. We exposed the temperature sensor to high temperatures to ensure its reliability, placed alcohol in the air quality sensor to verify its ability to detect these substances, and tested various sound clips to confirm the noise sensor's accuracy. Subsequently, after confirming the readiness of the sensors, we collected data by deploying a network of sensors, including the DHT11 temperature/humidity sensor, MQ-2 air quality sensor, and noise sensor unit, in two classrooms within King Saud University (KSU) especially at College of computer and Information Science (CCIS). These sensors continuously collect data related to temperature, air quality, and noise levels. The sensor data is then transmitted over Wi-Fi networks using the Internet of Things Messaging Protocol, enabling real-time data streaming to a central server. This data is then stored in our system's database, presented in a user-friendly charts format, and made accessible to building managers for effective monitoring of the building's internal environment.

1.5 Main Contribution

Our main contribution is the development of a comprehensive intelligent building monitoring system that caters to the needs of building managers in public buildings. Our solution offers several **unique advantages**:

- **Real-time monitoring:** Our system provides real-time data on temperature, air quality, and noise levels, allowing building managers to proactively address environmental issues.
- **Efficient use of space:** By providing insights into room availability and utilization, our solution helps building managers optimize space usage, which is especially critical in the context of fluctuating demand due to online learning.
- **Improved productivity and well-being:** By maintaining safe and comfortable indoor conditions, our solution contributes to increased productivity and well-being for faculty and students.
- **Modernity:** While there are building monitoring systems available, our solution's unique combination of hardware, software, and user-centric design sets it apart. It offers a comprehensive package tailored to the specific challenges faced by public building managers.

The impact of our solution extends to the local and global community:

Local Community: Building managers can better oversee public buildings, ensuring the safety and well-being of the people inside them. This contributes to providing a more comfortable and productive learning and working environment.

Global Community: The focus on sustainability and safety in public buildings aligns with global efforts to reduce environmental impact. By optimizing space usage and improving environmental conditions, we contribute to a more sustainable future.

In this document, we present a general background, literature review, competitive product analysis system description, and product backlog. Also we present system design , system implementation , system testing and conclusions and future work.

2 Background

Our project domain is Building Management system Specifically building monitoring systems(BMS). A Building Monitoring System (BMS) is an essential component of modern infrastructure, enabling facility managers and owners to monitor, control, and optimize a building's performance. By integrating various sensors, controllers, and software, a Building Management System (BMS) provides real-time information and analytics on the operation of various building systems, such as Heating, Ventilation, and Air Conditioning (HVAC) in addition to lighting, security, and energy management.Some of the benefits of a building management system can be summarized in the following points:

- Improved Occupant Comfort: By monitoring and controlling indoor environmental factors like temperature, humidity, and air quality, a Building Monitoring System BMS can enhance the comfort and well-being of building occupants.
- Preventive Maintenance: A BMS can detect irregularities and potential system failures, allowing for timely maintenance and reducing the risk of costly repairs or downtime.
- Cost Savings: A well-implemented BMS can result in significant cost savings through reduced energy consumption, optimized maintenance schedules, and improved space utilization.

and more, we can say that a Building Monitoring System is a critical investment for modern buildings, ensuring efficient operations, enhanced security, and improved occupant comfort. By leveraging advanced technologies, such as IoT, AI, and data analytics, Building Monitoring Systems (BMS) solutions continue to evolve and provide even greater benefits to building owners and occupants.

Building types vary greatly according to their uses, designs, and construction materials. Including: residential buildings, commercial buildings, public buildings and many types. We focus here on public buildings which include hospitals, schools, universities and more[8]. University buildings in Saudi Arabia can vary in size and complexity, but they typically require significant resources to operate and maintain. According to a statistical study conducted by the Ministry of Education in Saudi Arabia, university buildings account for a significant portion of total energy consumption in the country. The study found that many university buildings in Saudi Arabia are aging and require upgrades to reduce operating costs[9]. To address these challenges, there is a growing need for building monitoring systems that can help universities better manage their facilities. By implementing a building monitoring system, universities in Saudi Arabia can not only reduce operating costs but also improve the comfort and safety of building occupants, as well as reduce their environmental impact.

To manage such systems in university buildings, building managers play an important role in ensuring the safety of buildings. They are responsible for overseeing the day-to-day operations of the building and ensuring that all safety protocols are being followed. One of the biggest challenges that building managers face in monitoring university buildings is the

sheer scale of these structures. With so many different spaces and facilities to manage, it can be difficult to keep track of everything that needs to be done.
Overall, While there are challenges associated with monitoring these buildings, effective management can help to ensure that they continue to meet the needs of students, faculty, and staff.

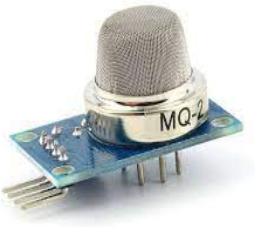
Here are some important terminologies used in our Elmam system :

- **Hardware:**

  1. **Sensors:** These are devices that measure various parameters such as temperature, air quality and noise. Sensors are an essential component of the BMS as they provide the data necessary for the system to make decisions about how to control the building's systems.

  - **Air quality sensor (MQ-2):** It is mainly used for the detection of gasses caused by fires and flammable gasses. Such as: methane, propane, liquefied petroleum gas, smoke, hydrogen[10].
  - **Temperature & humidity sensor (DH11):** Is a device that measures the temperature of the environment and converts this measurement into an electrical signal[11].
  - **Noise sensor (Sound detection sensor module)**: Also known as a sound level meter, it is a device that measures the intensity of sound in the environment[12].

Here is some general information about these sensors :

Sensors	General information	Measuring unit	Example
Air quality sensor	An air quality sensor is a device that measures the level of various pollutants in the air, such as particulate matter, volatile organic compounds, and carbon monoxide. Air quality sensors come in many different forms, from small, portable devices to larger, stationary units. Some common types of air quality sensors include: **Particulate matter sensors**: These sensors measure the level of fine particulate matter in the air, which can be harmful to human health. **Gas sensors**: These sensors measure the level of various gasses in the air, such as carbon monoxide, nitrogen dioxide, and ozone. **Volatile organic compound (VOC) sensors**: These sensors measure the level of organic compounds in the air, such as those emitted by paints, cleaning products, and other household items. Air quality sensors can be used in a variety of applications, from monitoring air quality in homes and workplaces to measuring pollution levels in indoor and outdoor environments. They can provide valuable information about air quality and help	The measuring unit of an air quality sensor depends on the specific pollutant being measured and the type of sensor being used. **Particulate Matter**: The measure for particulate matter is usually given in units of micrograms per cubic meter (µg/m³). This measure represents the concentration of particles with a diameter of 2.5 micrometers or less (PM2.5) or 10 micrometers or less (PM10) in the air. **Gasses sensor** : The measure for gasses such as carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and ozone (O3) is usually given in units of parts per million (ppm) or parts per billion (ppb). **Volatile Organic Compounds (VOCs)**: The measure for volatile organic compounds is usually given in units of parts per million (ppm) or parts per billion (ppb).	 **MQ-2 sensor**

	individuals and organizations make informed decisions to improve air quality and protect human health.		
Temperature & humidity sensor (DH22)	A temperature and humidity sensor is a device that measures the level of moisture and heat in the air. These sensors are commonly used in indoor environments, such as homes, offices, and greenhouses, to monitor the temperature and humidity levels and ensure a comfortable and healthy living or working environment. Temperature and humidity sensors come in different forms, but the most common type is a combined sensor that measures both temperature and humidity. These sensors use various technologies to measure temperature and humidity, such as thermistors and capacitive sensors.	Temperature is typically measured in degrees Celsius (°C) or Fahrenheit (°F). Celsius is the most common unit of measurement for temperature sensors. Humidity is typically measured in relative humidity (%RH), which is expressed as a percentage. Relative humidity indicates the amount of moisture in the air relative to the maximum amount of moisture the air can hold at a given temperature.	 **DHT22 sensor**
Noise sensor (Sound detection sensor module)	A noise sensor is an electronic device that measures the level of sound or noise in an environment. These sensors are commonly used in various applications, such as noise pollution monitoring, building acoustics, and industrial noise control. A noise sensor can measure sound levels in different ways, depending on the type of sensor and the application. Some common types of noise sensors	The measuring unit of a noise sensor is the decibel (dB). Decibels are a logarithmic unit of measurement that expresses the ratio of the sound pressure level to a reference level.which means that a sound with a level that is 10 times greater than the reference level. The reference level is typically a sound pressure of 20	 **Sound sensor**

	include: **Microphone-based sensors**: These sensors use a microphone to measure sound waves and convert them into electrical signals, which are then processed to determine the sound level. The microphone can be either an omnidirectional or a directional microphone, depending on the application. **Vibration-based sensors**: These sensors measure the vibration caused by sound waves in a structure or surface. They can be used to measure noise levels in buildings or machinery, where it is difficult to use a microphone-based sensor. **MEMS-based sensors**: These sensors use micro-electromechanical systems (MEMS) technology to measure the sound pressure level. They are small in size and can be integrated into portable devices or wearables.	micropascals, which is the threshold of human hearing at a frequency of 1,000 Hz.	

Table 2.1 General information about sensor

2. **Microprocessors:**

- **Raspberry pi 3 (Model B Board)***:* Is a computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins, allowing you to control electronic components for physical computing and explore the Internet of Things (IoT).
- **ESP 8266** *:* Is a low-cost, low-power, Wi-Fi-enabled microcontroller chip. It is designed to be used in Internet of Things (IoT) devices and can be programmed to perform a wide range of tasks, such as connecting to Wi-Fi networks, communicating with other devices over the internet, and collecting and processing sensor data.

Important definition :

- **Internet of Things (IoT):** A network of interconnected devices that can communicate with each other and exchange data. In the context of building management systems, IoT can be used to connect sensors and devices to a centralized control system.
- **Building Automation System (BAS):** Another term for Building Management System (BMS), which refers to the use of advanced technologies to control and monitor building systems.
- **Data Analysis:** Data analysis in BMS (Building Management Systems) involves collecting, processing, and interpreting data from various sensors and devices to optimize building performance. The data collected from BMS (Building Management Systems) sensors and devices can be analyzed to identify patterns and more. This analysis can provide valuable insights into building performance.
- **Computer programming:** Building management systems rely heavily on computer programming. Understanding programming languages, such as Java or Python, is necessary for designing and implementing building management systems.

Overall, building management systems require a combination of technical and programming skills, as well as an understanding of building systems. By having a good understanding of these domain knowledge areas, we can design and implement an effective BMS that optimizes building performance.

In our Elmam building monitoring system we are going to monitor different classes in KSU (King Saud University) - building 6 (collage of computer and information science) in the ground floor, we are going to choose two of these classes in different directions (6G18 , 6G09 , 6G35).

Room number	Type	Why this?	The room in the map
6G18	Seminar room	This room has one large window, which helps us monitor the temperature as this room will be exposed to sunlight since the window is located vertically. Therefore, the temperature in this room will be high. In addition, the window in this room is not easily opened, which may prevent sunlight from entering the room to a large extent.	You can find it in Appendix C: Data collected
6G09	classroom	The size of this room is considered small compared to other rooms, and it has one small window that is easy to open.Therefore, this room may be more exposed to sunlight, as its size is small and sunlight can easily enter. When monitoring the temperature, the temperature will be high.	You can find it in Appendix C: Data collected
6G35	Lab	This laboratory has three windows of the same size, and these windows are easy to open, allowing sunlight to enter the laboratory. This may increase the temperature in the laboratory.	You can find it in Appendix C: Data collected

Table 2.2 Classes to monitor

3 Literature Review

The traditional way of managing a building takes time and effort. It is a difficult process for building managers. Modernly, it has become easier and more convenient with the help of modern technologies. We will discuss similar Systems related to our project to build a system capable of providing the best services and user experience to building managers. We will evaluate these systems based on their advantages and disadvantages.

3.1 Competitive Product Analysis

Some competitors have a similar concept to our system, which will be discussed below, to make sure we have a competitive advantage. We find 5 competitors as shown below:

- (Mouwasat hospital system)

  Mouwasat Hospital [3], as shown in figure 3.1 is a private hospital located in Saudi Arabia that offers various medical services to its patients. The hospital has implemented a Building Management System (BMS) to manage and control the various systems and equipment within the hospital building. The Building Management System (BMS) installed in Mouwasat Hospital is a computer-based control system that monitors and controls various building systems, such as heating, ventilation, and air conditioning (HVAC), lighting, fire safety, and security. The system is designed to improve energy efficiency, reduce operating costs, and provide a comfortable and safe environment for patients, staff, and visitors.

  In the table below, we have detailed the advantages and disadvantages of this system:

System	Advantedge	Disadvantage
Mouwasat hospital	1-Enhanced visitor comfort: The system offers building management to maintain a comfortable environment for patients, staff and visitors by regulating temperature, humidity and lighting levels. 2- The system has an AI-based cloud which is a platform that predicts maintenance issues, overcooling/heating and sensor malfunction. 3- The system has Alarm Management that monitors potentially dangerous situations and processes value deviations. 4-Increase safety and security: The system can manage buildings and monitor and control security and fire safety systems, such as access control, closed-circuit television, and alarm systems, which can help enhance safety and security within the hospital building.	1- The system uses cameras to monitor the internal environment of the building, which may cause disturbance to the visitors of the building. 2-The system is complex and requires specialized skills and knowledge to operate and maintain. 3-High installation and maintenance costs.

Table 3.1 Mouwasat hospital Advantages/Disadvantages

Figure 3.1 Mouwasat Building Management System

- (jsaas-safety.com)

  Jsaas-safety.com [4] is a company that provides safety and risk management services to various industries, including healthcare, construction, and oil and gas. The website, as shown in figure.3.2 provides information about their Building Management System (BMS) services, which include the installation, maintenance, and optimization of BMS systems for various types of buildings. The BMS services offered by JSAAS Safety Consultancy aim to help clients improve energy efficiency, reduce operating costs, and enhance occupant comfort and safety.

  In the table below, we have detailed the advantages and disadvantages of this system:

System	Advantedge	Disadvantage
Jsaas-safety system	1 - The system has the ability to control many things such as: elevator management ,theft alarm system and access control system. 2 - The system Certified by the civil defense for fire fighting systems and fire alarm Systems. 3- They have an expert team. The team can improve BMS systems to help customers increase energy efficiency and	1- The system uses cameras and sounds to monitor the internal environment of the building, which may cause disturbance to the visitors of the building. 2- It depends entirely on technology and there are no human decisions unlike our system, which contains human decisions in the event that it is exposed to any dangerous

	reduce operating costs.	symptoms of the internal environment, which means that their system may be vulnerable to technical problems or electronic attacks that could affect its performance.

Table 3.2 Jsaas-safety system Advantages/Disadvantages

Figure 3.2 Jsaas-safety system

- (King AbdulAziz University Building Management System)
  King Abdulaziz University (KAU) in Saudi Arabia, which provides information about their Building Management System (BMS) [5]. The BMS at KAU is capable of integrating with various subsystems, such as power distribution, elevators, and access control systems. The system uses sensors, controllers, and actuators to monitor and control the various building systems as shown in figure 3.3 It also provides real-time data and analytics to help facility managers make informed decisions about building operations and maintenance.

  In the table below, we have detailed the advantages and disadvantages of this system:

System	Advantedge	Disadvantage
King AbdulAziz University system	1- The system controlling elevators and connecting with low current systems such as surveillance cameras and audio. 2 - Other features include the access control system and the fire alarm system through one integrated system. 3-The number of buildings connected to the system is 42 buildings within the university campus.	1- The system uses cameras and sounds to monitor the internal environment of the building, which may cause disturbance to the students in the university.

Table 3.3 King AbdulAziz University system Advantages/Disadvantages

Figure 3.3 King AbdulAziz University Building Management System

- (Tacoma Building Management System)

  Tacoma[6] is a comprehensive building monitoring system designed to oversee and control all electromechanical loads, including ventilation, air conditioning, heating, lighting, and elevators. It seamlessly integrates with low-current systems, such as surveillance cameras, audio systems, burglar alarms, access control systems, and fire alarm systems, creating a unified and integrated solution for efficient building management as shown in figure 3.4.

  In the table below, we have detailed the advantages and disadvantages of this system:

System	Advantedge	Disadvantage
Tacoma system	1-The system includes access control to the building (fingerprint or card), which facilitates the process of ensuring that only authorized persons enter.	1- The system does not compromise the privacy of building visitors by employing cameras to monitor environmental conditions. 2-The system relies on technology, devices, and pumps to

	2-The system contains security and anti-theft systems, which makes moving inside the building safer. 3-The system contains a timer to start and stop the systems to be controlled, which reduces operational costs within the building.	minimize the need for numerous operators in management operations. However, this reduction in staffing poses challenges for decision-making in critical situations, especially given the limited number of administrators compared to the expansive size of the buildings where the system is implemented, such as universities and hospitals.

Table 3.4 Tacoma system Advantages/Disadvantages

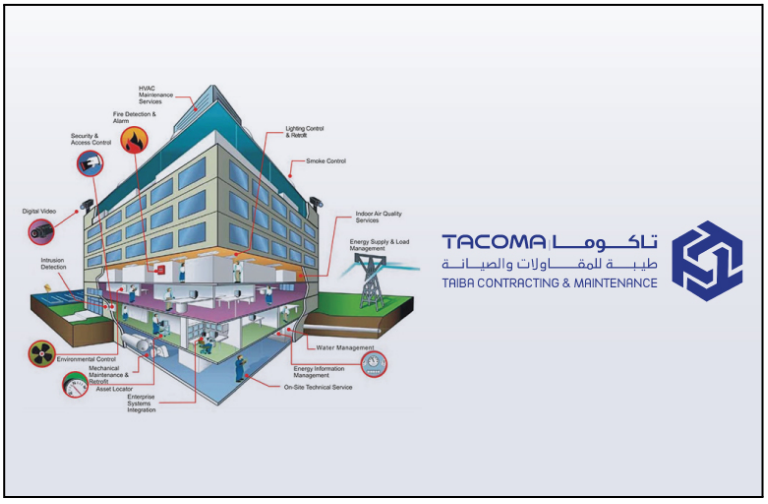


Figure 3.4 Tacoma Building Management System

- (King Saud University Building Management System)

  The KSU system[7] is a centralized system designed for monitoring, controlling, operating, and managing all activities within a building or facility. It encompasses centralized control and monitoring of all electromechanical loads, such as Heating, Ventilation, and Air Conditioning (HVAC) systems, including pumps, chillers, air handling units, and air flow control devices. Additionally, it includes monitoring and control of low-current systems like Access Control Systems and Fire Alarm Systems.

  In the table below, we have detailed the advantages and disadvantages of this system:

System	Advantedge	Disadvantage
King Saud University system	1-In the system there is a connection between the building management system and other systems such as: the fire alarm system, as the system gives specific orders in the event of a fire alarm. 2-The system provides 24/7 technical Support for all operational processes of various systems around the clock. 3-The system optimizes equipment and system operation based on building/facility requirements, leading to reduced energy consumption.	1-The system has high installation and maintenance costs.

Table 3.5 King Saud University system Advantages/Disadvantages

Figure 3.5 King Saud University Building Management System

To compare our system with the competitors to find what is the advantages of our system:

Service/Feature	Mouwasat hospital	King AbdulAziz University	Jsaas safety	Tacoma	King Saud University	Elmam
Monitor temperature/humidity.	✓	✓	✓	✓	✓	✓
Monitor Noise (sounds).	✓	✓	✓			✓
Monitor Air Quality.	✓			✓	✓	✓
Report an alert if there is a potential problem	✓	✓	✓	✓	✓	✓
Provide a report that summarizes building statistics .	✓	✓				✓
Preserving privacy.					✓	✓
Display an interactive map of the buildings						✓
Show the occupancy status of the room and aid in the efficient management of building spaces.						✓

Table 3.6 Comparing Software

4 System Design and Development

4.1 Methodology

Due to our desire to produce a high-quality functioning system,Elmam was developed using the agile software development process,which allows developers to deliver value to customers faster and with fewer issues through continuous evaluation of requirements, plans, learning, and results.As a result, we were able to break down the project into smaller, more manageable units, allowing us to concentrate on the design, implementation, and testing of one unit at a time before integrating the units and testing them as a whole to create a completed, functioning system.

We used the scrum framework as an agile practice to direct the development of Elmam system. The initial step was to establish the scrum team, which included the product owner who was in charge of supervising the thorough implementation of the system as well as assessing the user stories and acceptance criteria. The scrum master was in charge of ensuring that the team was following the scrum framework correctly and resolving any obstacles they encountered. Finally, developers were in charge of carrying out the work, making the necessary adjustments, writing and breaking down user stories, and producing the final product.

Following the team formation, the project was divided into sprints. Each sprint consisted of five events, beginning with planning, where we decided what would be worked on during the sprint as well as what would be delivered at the end of each sprint. Next, we reviewed the daily workflow during the daily scrum. After that, the community evaluated the project's progress during the sprint review. Finally, the sprint concluded with a retrospective, where we assessed our own performance.

As for the scrum artifacts, we first established the product backlog, where we wrote all the features as user stories and prioritized them based on importance. Then, we selected a group of features for each sprint based on the type of feature and dependencies. Finally, at the conclusion of each sprint, we integrated the features with one another and then with the remaining user stories that had been completed during the previous sprints. That's what was accomplished in the Product Increment.

A successful step for our project was the adoption of agile approach. Through it, we were able to attain a very significant objective, which was to involve users in the development of Elmam system in which we were able to hear their feedback and adjust the application accordingly.

Since agile approaches focus on the important functions before diving into the details, as well as the requirement that all team members commit to attend the scrum master's meetings, weekly meetings with the product owner, and daily meetings to monitor workflow, we were also able to deliver a system that functions in a short period of time. The team members themselves determined how the work would be divided, thus the trust of the product owner provided them the freedom to do so in accordance with their capabilities and skills. As a result, the work was completed in the proper manner.

GitHub and Jira are two of the most significant tools and websites that supported us during the development of Elmam. We were able to manage and build the system more easily because of their utilization. With regard to Jira[6] , it allowed us to create user stories, allocate them into sprints, and write reports about our weekly meetings with the product owner. With regard to GitHub[7] , we were able to assign a branch to each team member so they could upload their work there. This allowed us to merge the work so that the codes did not overlap, also the work remained orderly, and it was kept safe from loss.

[6] Jira link [GP2 board - Agile board - Jira (atlassian.net)].
[7] GitHub repository [https://github.com/sara2alharbi/2023-GP1-2/tree/master].

4.2 System Requirements

4.2.1 System Users

The intended users of our system are primarily Arabic-speaking building managers and decision-makers, aged 25 and above, who hold a bachelor's degree and possess a strong technical background in website administration. Elmam is designed to assist building managers facing challenges related to space utilization and maintaining optimal environmental conditions within their buildings. The system also targets those who need to efficiently manage their buildings to ensure residents and visitors' satisfaction.

Elmam provides building managers with precise measurements of key environmental parameters, including temperature, humidity, air quality, and noise levels within various rooms. These measurements are critical for creating a comfortable and healthy indoor environment. Monitoring noise levels can also aid managers in optimizing space usage. For instance, Elmam can send alerts to managers if it detects an absence of noise in a reserved room, indicating that the space is not being utilized.

Furthermore, Elmam plays a crucial role in maintaining a comfortable indoor environment for students and employees in schools and colleges, without compromising their privacy.

Elmam caters to a specific user group—experienced building managers and decision-makers—who require data-driven solutions for efficient space management and maintaining ideal indoor conditions.

4.2.2 Requirements Elicitation and Analysis

For eliciting requirements, we decided to use both interviews and questionnaires as methods to elicit our requirements since questionnaires reach people quickly and inexpensively and can help us cover a large segment of users (students/employees/building managers) in a short time.
For interviews, we will be able to collect more detailed information on building managers and this will allow us to better understand the desires and needs of our users. We will provide more details about the interviews and the questionnaire in the Appendix.
We constructed a survey by using Google Forms. Our survey consists of 3 general questions , 9 questions for students/ employees and 17 questions for building managers. It was distributed through the internet so users can answer it easily from that survey, we received 100 responses for the survey. In the first section shown in Appendix B, we asked them general questions, as our solution targets Saudis public buildings, and we found that 100% of people

reside in the Kingdom of Saudi Arabia, and we also asked them about their age group, so we found that 34% were between 20-29 , 25% are more than 40 , 24% are between 30-39 and 17% are less than 20 . Also we asked them about their job title, so we found that 63% are students/ employees and 37% are building managers.

For the students and employees section , firstly we asked them if the number of public buildings are increasing at the present time and most of them agreed with it. Also most of them visit public buildings such as (universities, companies or schools) on a daily basis. However, we found that they are facing problems in terms of temperature and air quality in public buildings. Then we found that a lot of them care about the indoor environment in the building, such as air quality and temperature. Also , many of them get upset if the room temperature is not suitable for them. In addition, lots of them are affected by the air quality in the room like dust. Lastly, we asked them if they face difficulty in improving the internal environment of the room inside the building such as (air quality) and about 63.5% responded with yes.

For the building managers sections (attached in Appendix B) , we found most of them have difficulty in managing tasks in the building. About 65% of the building managers disagree that building is managed in a way that helps achieve space utilization. We asked them if they had problems with booking classes and passive labs reservation and almost 59.5% of them facing this problem, 37.8% responded sometimes and 44.4% of those who face these problems said the rate of booking classes and passive labs is between 2-4. Also, we asked them if they think that the use of laboratories/classrooms in the building by unauthorized persons may lead to problems and 89.2% responded agreed. Close to 92% of them received complaints about the temperature in the laboratory /classrooms: cold - extreme heat, the ones who answered yes which are 30.6% of the building managers received complaints about temperature, where the rate of complaints ranged from 4 to 6 complaints within a week In one semester. We asked them if they received complaints about the air quality in the lab/ classrooms and most of them agreed. About 81.1% of them received complaints other than those mentioned in the questionnaire and 10.8% of them sometimes received other complaints. Last semester, close to half of them received between 2-4 complaints every week in regards to the internal environment of the building. About 62.2% of them have difficulty receiving the weekly quality statistics summary report of the building and 29.7% of them sometimes face it. Lastly, more than 80% of them agreed that if there is a system to solve the above problems it will help them in managing these problems.

For managers' interviews (attached in Appendix A) we interviewed 3 people, we found that they have different tasks based on their job (building manager/school manager) such as ensuring the security of the building facilities, periodic maintenance and taking into account the convenient indoor environment and most of them mentioned that it will be easier if there is a technical solution to help in their tasks. The biggest problems and challenges they face as managers are to control maintenance costs and breakdowns based on their budget, also making people in the environment satisfied. Most of the complaints they received are about the temperature in the rooms, while the others received complaints about lack of maintenance and bad smells. We found that most of them have difficulties in managing buildings efficiently because of the lack of technical solutions that help them to monitor these buildings remotely. Most of them agreed that the unauthorized entry/using spaces by students/visitors at unspecified/reserved times will affect their tasks negatively, the impact lies in consuming energy and the exposure of the building's equipment to misuse or sometimes its destruction. They all agreed that the air quality affects their tasks which can cause general discomfort and a range of negative health effects (such as lack of focus while doing their tasks). All of them agreed that the temperature in spaces may affect their/visitors focus and the progress of the educational process. Moreover, all of their answers agreed that ensuring room status remotely (busy or not) at the scheduled time helps in organizing plans for the semester and also to ensure space utilization of the building. We found that all of them didn't use a building management system before. We asked them if there will be a new system that helps them in the process of managing the building, and what features and services would be in it, and some of them mentioned monitoring and managing reservations and their timing, while others bring up providing notifications in the event of risks, with information available remotely such as temperature, air quality, numbers of rooms, and device maintenance status. In conclusion, all of them agreed that using a technical solution and smart building concepts (ex: sensors to monitor building spaces) will improve the quality of the internal environment of the building.

4.2.3 User Interactions

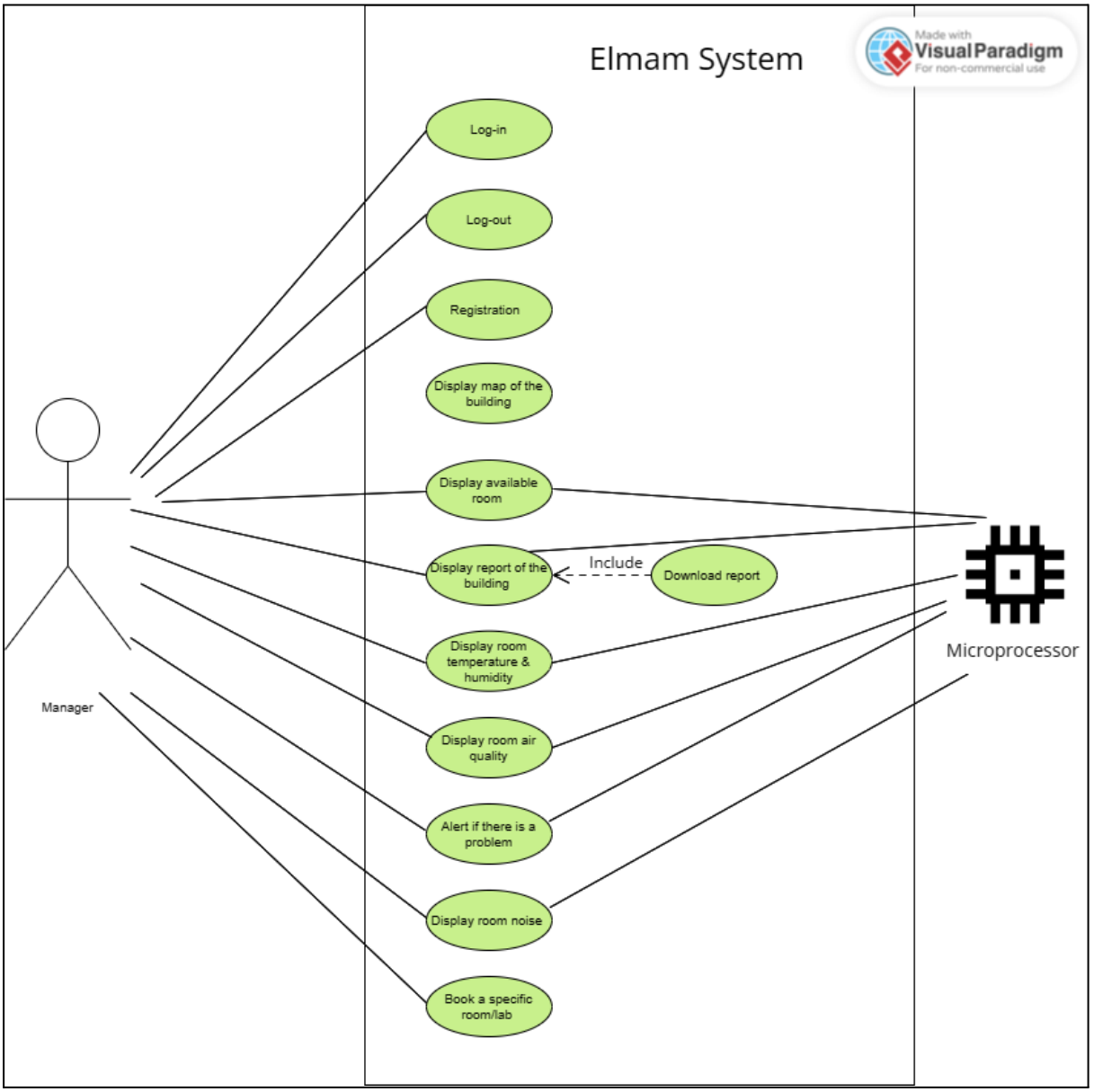


Figure 4.1 Use case diagram

4.2.4 Roadmap and Product Backlog

- Roadmap

  This section outlines our project's road map as shown in table 4.1 and figure 4.2 which includes sprints, task distribution during the sprints, and delivery dates.

Sprint#	date	Goal	Feature
Sprint 0	26th Mar	The objective of Sprint 0 is to comprehensively delve into the background of the domain. This includes gaining a profound understanding of the existing context, acquiring proficiency in the new programming language, conducting a thorough examination of the system users, and making informed decisions regarding the selection and procurement of hardware devices such as sensors and microprocessors. This preparatory phase lays a solid foundation for the subsequent sprints, ensuring a well-informed and strategic approach to the project's development.	--
Sprint 1	26th Apr	The goal of sprint 1 is to collect offline data, design the IOT platform, design building managers interface,inspect and test the sensors .	--
Sprint 2 (Product 1st release)	21th May	The goal of sprint 2 is to show live streams of sensor events,establish a connection between microprocessor and cloud,and develop building managers tasks that let the	1. Building managers can signup/login/logout on the website. 2. Building managers can display

		manager have an account in the system.	temperature /humidity /air quality and noise. 3. Building managers can display a list of all the rooms in the building.
Sprint 3	20th Aug	The goal of sprint 3 is to design the database to store all sensor data and continue to develop building managers tasks.	1. Building managers can display an interactive map of the building. 2. Building managers can display a temperature during a specific date. 3. Building managers can display temperature , air quality and noise based on the room.
Sprint 4	25th Sep	The goal of Sprint 4 is to enhance the building management system by implementing a weekly report feature summarizing building statistics. This includes the ability for building managers to download the report, report an alert if there is any potential problem, and show room occupancy based on both schedule and noise sensor data. Additionally, the sprint aims to introduce the functionality for building managers to book rooms or labs, considering specific time slots, capacity, and room numbers.	1. Building managers can display and implement a weekly report feature that summarizes building statistics. 2. Building managers can download the report. 3. Building managers can report an alert if there is a potential problem. 4. Building managers can display rooms occupied or available based on schedule. 5. Building managers

			can display rooms occupied or available based on noise sensors. 6. **Additional :** Building managers can book a room or a lab in a specific time and based on specific capacity or based on room number.
Sprint 5 (Product 2nd release)	5th Nov	The goal of sprint 5 is to test the system and finalize the project documentation.	1. Building Managers can do all their functions.

Table 4.1 Roadmap table

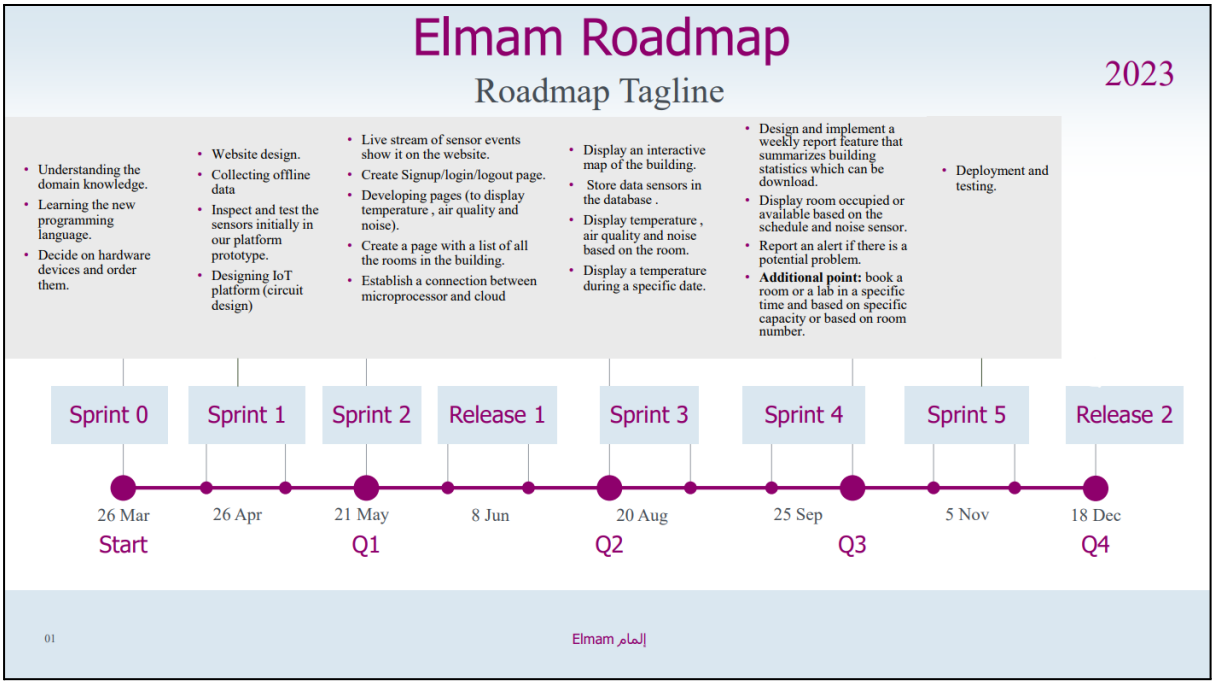


Figure 4.2 Roadmap

- Product Backlog

ID	PBI (user story)	Size	Type (Feature, defect, technical work, knowledge acquisition)	Status (To do,in progress,or Done)	Acceptance Criteria The conditions of satisfaction that must be met for that item to be accepted.
1	- **As a** building manager, **I want to** be able to sign-up to the system **so that** I can have a profile on Elmam website and use its features.	1	feature	Done	• As a building manager, if I go to the sign-up page and enter my name, email, password,confirm password then click on the register button, then I should have an account on the Elmam website, and a confirmation message should appear. • If I did not enter one or all of the following: my name, email, password and confirm password, then I click the sign-up button then an error message should appear. • If I enter an already used email, then an error message should appear. • If I enter password length less than 8 in the password, then an error message should appear. • if I enter a different password in the conformation of the password then an error message should appear.
	- **As a** building manager in Elmam website, **I want to** be able to	1	feature	Done	• As a building manager If I go to the log-in page and click on the log-in button, enter my Email, and password correctly

2	log-in to my account **so that** I can use the website features.				then I should be signed into my account in Elmam website. • If I go to the log-in page, click on the log-in button, select a different entered Email and password wrong, then I won't be able to log in and an error message should appear.
3	- **As a building** manager on the Elmam website , **I would** like to be able to log out, **so that** I can leave the website.	1	feature	Done	• As a building manager If I go to log-out and click on the log-out button then I will be logged out.
4	- **As a** building manager on Elmam website, **I want to** be able to display a report that summarizes building statistics **so that** I can know the status of the building.	3	feature	Done	• As a building manager If I click a report page then I choose a specific room it will display the weekly report of the building.
5	- **As a** building manager on Elmam website, **I want to** be able to download a report that summarizes building statistics **so that** I can save and discuss it	1	feature	Done	• As a building manager If I click a report page then I choose a specific room it will display the weekly report with a download button at the end of the page.

	with decision makers.				
6	- **As a** building manager on Elmam website, **I want to** be able to display the room temperature/ humidity **so that** I can know the temperature/humidity for a specific room .	2	feature	Done	• As a building manager, If I click on the monitor indoor environment button from the menu then I choose a specific room it will display the current temperature/humidity .
7	- **As a** building manager on Elmam website, **I want to** be able to display the room air quality **so that** I can know the air quality for a specific room.	2	feature	Done	• As a building manager, If I click on the monitor indoor environment button from the menu then I choose a specific room it will display the air quality in this room.
8	- **As a** building manager on Elmam website, **I want to** be able to display the room's noise level **so that** I can know the noise for a specific room.	2	feature	Done	• As a building manager, If I click on the monitor indoor environment button from the menu then I choose a specific room it will display the noise level in this room.

9	- **As a** building manager on Elmam website, **I want** to be able to display the available room based on schedule **so that I** can know if the room is occupied or not.	1	feature	Done	• As a building manager, If I click on room status then it will display the rooms availability based on schedule.
10	- **As a** building manager on Elmam website, **I want** to be able to display the available room based on noise sensor **so that I** can know if the room is occupied or not.	2	feature	Done	• As a building manager, If I click on room status then it will display the rooms availability based on live noise sensor data.
11	- **As a** building manager on Elmam website, **I want to** be able to display the interactive floor-map **so that** I can easily find a specific room in the building.	1	feature	Done	• As a building manager ,If I click on the floor-map button from the menu then I choose a specific floor it will display an interactive floor-map of the building.

12	- **As a** building manager on Elmam website, **I want to** be able to alert me if there is a potential problem related to the quality of the room **so that** I can know the potential problem in the building.	2	feature	Done	• As a building manager, If I log into the Elmam system it will display an alert with red color if there is any potential problem. • As a building manager, If I click the notification button from the menu it will display a table that contains recent notifications.
13	- **As a** building manager on Elmam website, **I want to** be able to display the room temperature and noise based on date **so that** I can know the temperature and noise for a specific room on this date .	2	Feature	Done	• As a building manager, If I click on the temperature and noise readings button from the menu then I choose a specific room and date it will display a chart that contains temperature and noise on this date.
14	- **As a** building manager Elmam website, I want to book a specific room **so that** I can know if the room is available or not.	2	Feature	Done	• As a building manager, If I click on a book room button from the menu then I choose the way of book room (capacity or room number and semster) it will display the available rooms based on my choice.

Non-functional requirements					
15	- **As a** building manager, **I want** the website to be available 99% when I try to use it **so that** I don't become upset and switch to another site.	-	Feature (availability)	Done	• If I want to use the website, then it must be available about 99% of the time.
16	- **As a** user of Elmam website , **I want** the website to process any request within less than 4 seconds **So that** I don't get irritated.	-	Feature (performance)	Done	• As a user of the Elmam website if I send a request then the website should respond within less than 4 seconds.
17	- **As a** user of the Elmam system, **I want** my account to be secured **So that** it can be protected from unauthorized access.	-	Feature (security)	Done	• As a user of the Elmam system, if I signed up then my password should be encrypted.

18	- **As a** user of the Elmam system, **I want** the Elmam system to perform without failure in 90% of use cases **so that** I can use the website in an efficient way .	-	Feature (reliability)	Done	• As a user of Elmam system, if I use the Elmam system then I must be able to use the Website by 90% without failure.
19	- **As a** user of the Elmam system **I want** the website to be clear to use, **so that** I can interact with the interface easily within an average of 1 minute.	-	Feature (usability)	Done	• As a user of Elmam system, if I use the Elmam system then I must be able to use the system within an average of 1 minute.

Table 4.2 product backlog

4.3 System Design

4.3.1 Architectural Diagram

Elmam is a system including a website, in Elmam we are using Client-Server architecture. This pattern consists of three parts: server, clients and network, where many clients request and receive services through the network from a centralized server which is suitable for our system because it will be easy to modify and store data. Also, the access to the file's such as reports will be simple since they are all kept in a single server. We have three sensors: temperature/humidity, noise and air quality that are connected to a microprocessor and a shared database which can be accessed from a range of locations to store the data from sensors, store building information and serve building managers by responding to their requests. The Elmam system provides an interface that allows a user (ex: building manager) to request services such as the statistics/results of monitored rooms. We have many non-functional requirements of the system, such as performance and availability so the client-server is the best option, one of its main advantages is that the servers can be distributed across the network and general functionality (e.g, display report) can be available to all clients.

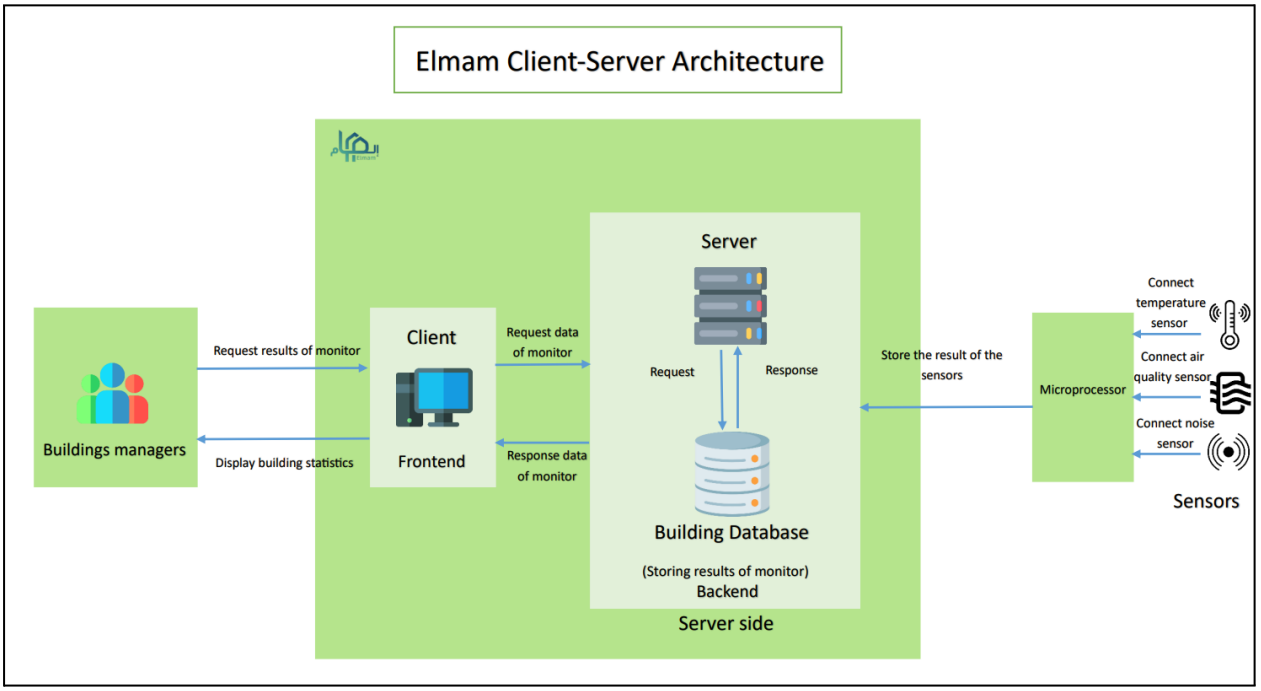


Figure 4.3 Elmam System Architecture

4.3.2 Class Diagram /DFD

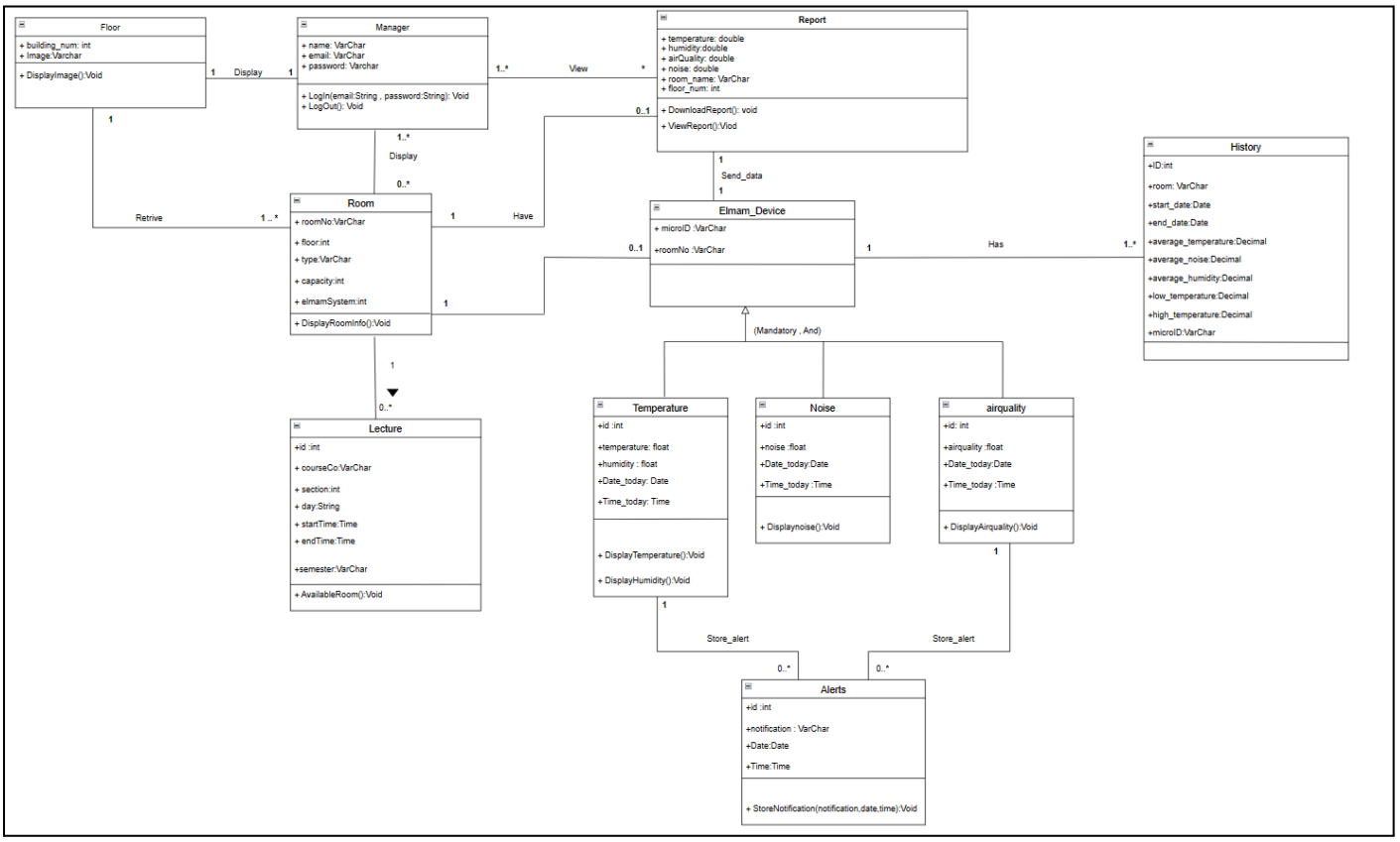


Figure 4.4 Elmam System class diagram

4.3.3 Component Level Design

- **As a** building manager, **I want** to be able to log-in and sign-up to my account **so that** I can use the website features.

BEGIN
Display log-in page
    IF has an account **THEN**
    GET Email & Password
        IF (Email == Entered Email && Password == Entered Password) **THEN**
            Display manager home page
        END IF
        ELSE
            Display Error message
            Display log-in page
    END IF
    ELSE
    GET Name & Email & Password
        IF valid inputs **THEN**
            Display manager home page
        End IF
        ELSE
            Display Error message
            Display log-in page
END

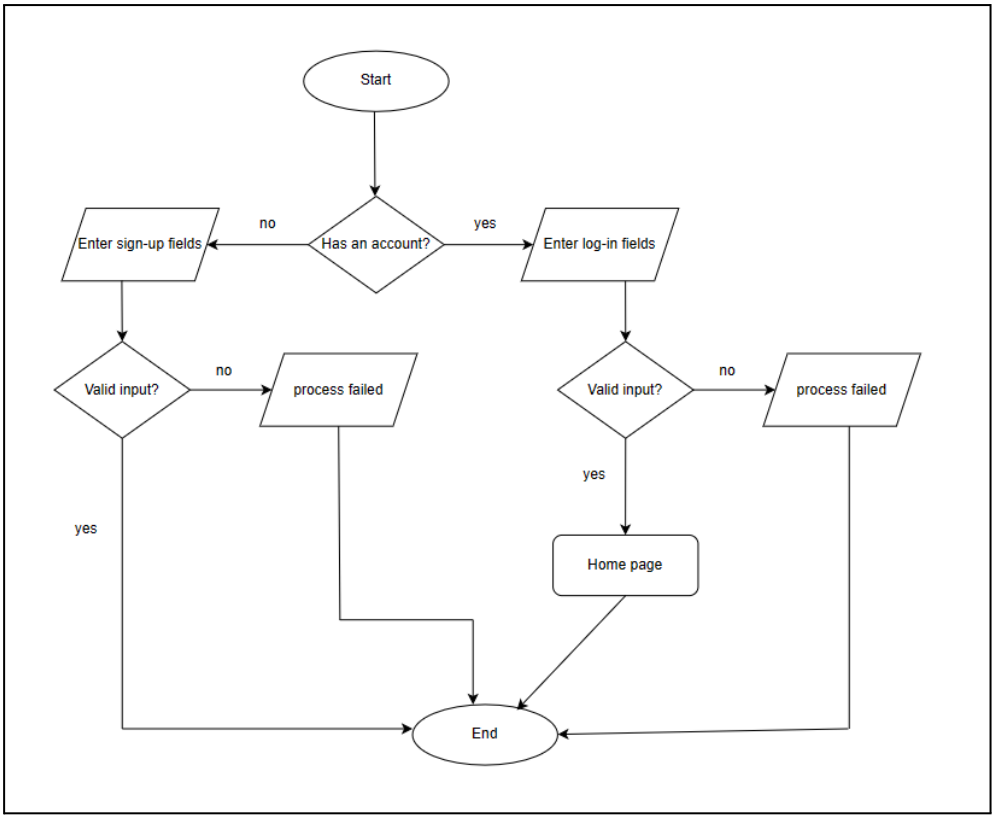


Figure 4.5 log-in flowchart

- **As a** building manager on Elmam website, **I want to** be able to display a report that summarizes building statistics **so that** I can know the status of the building.

  BEGIN
  DISPLAY Manager dashboard **THEN**
  Click on weekly report **THEN**
  prompt the manager Choose room **THEN**
  Connect to the database
  Execute the SQL query
  Process the receive data
  Close the database connection
  DISPLAY the report for the specific room
  END

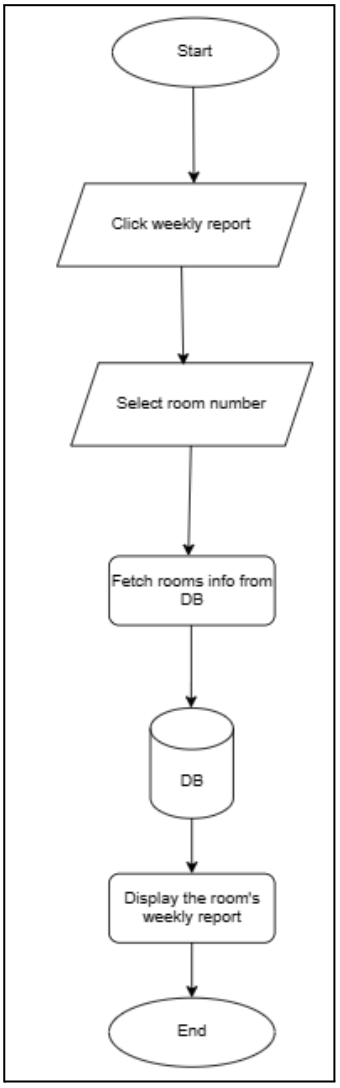


Figure 4.6 Report flowchart

- **As a** building manager on Elmam website, **I want to** be able to display the room temperature and noise based on date **so that** I can know the temperature and noise for a specific room on this date .

BEGIN
DISPLAY Manager dashboard **THEN**
Click on Room in the building
Click on temperature and noise readings
prompt the manager to choose the room & date **THEN**
Connect to the database
Execute the SQL query
Process the receive data
Close the database connection
DISPLAY the data in charts
END

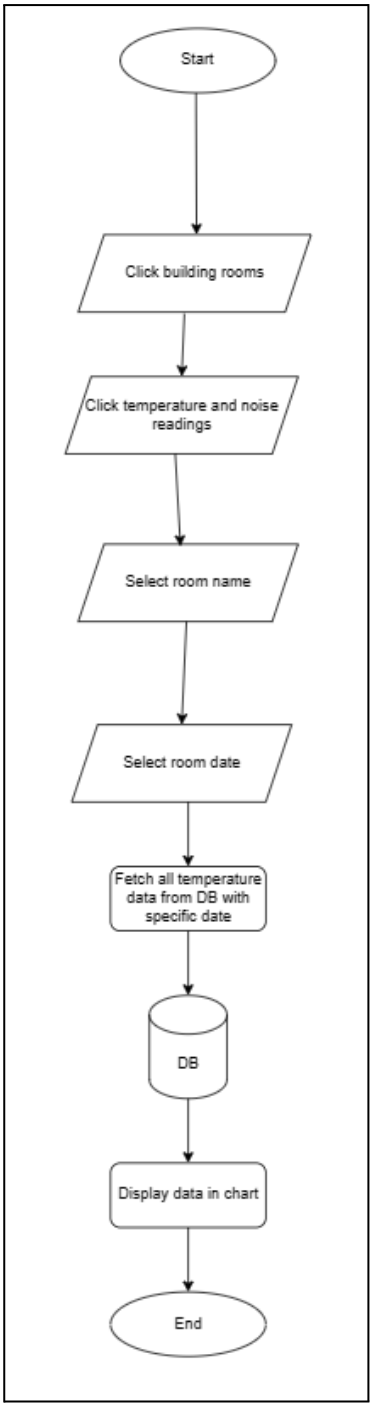


Figure 4.7 Temperature and noise charts flowchart

- **As a** building manager Elmam website, I want to book a specific room **so that** I can know if the room is available or not.

BEGIN
DISPLAY Manager dashboard **THEN**
Click on Room in the building
Click on book room
prompt the manager to choose book by room number or capacity
THEN
prompt the manager to enter the reservation information **THEN**
Connect to the database
Execute the SQL query
Process the receive data
Close the database connection
DISPLAY all available room
END

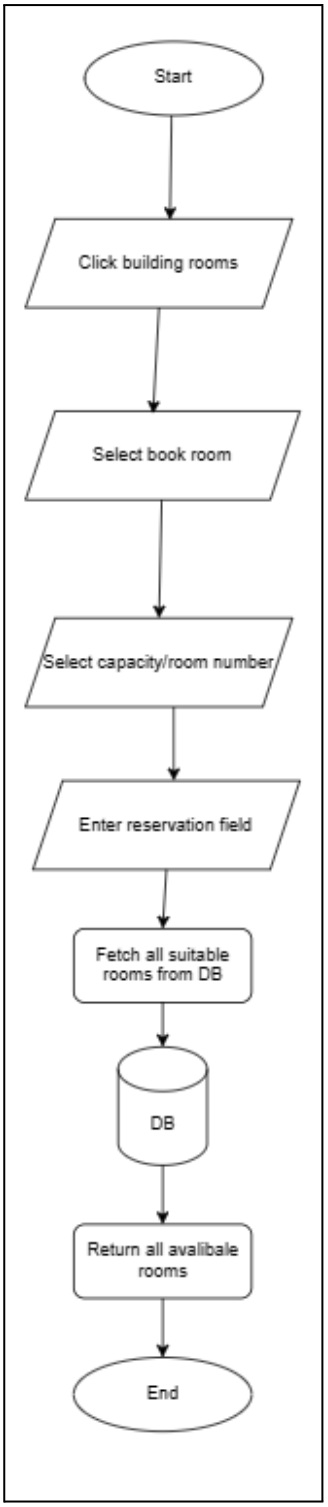


Figure 4.8 Book room flowchart

- **As a** building manager on Elmam website, **I want to** be able to know the room information from the interactive map , **so that** I can get all the room information .

BEGIN
DISPLAY Manager dashboard **THEN**
Click on map of the building
prompt the manager to choose the floor number **THEN**
prompt the manager to select the room number **THEN**
Connect to the database
Execute the SQL query
Process the receive data
Close the database connection
DISPLAY room information in the map
END

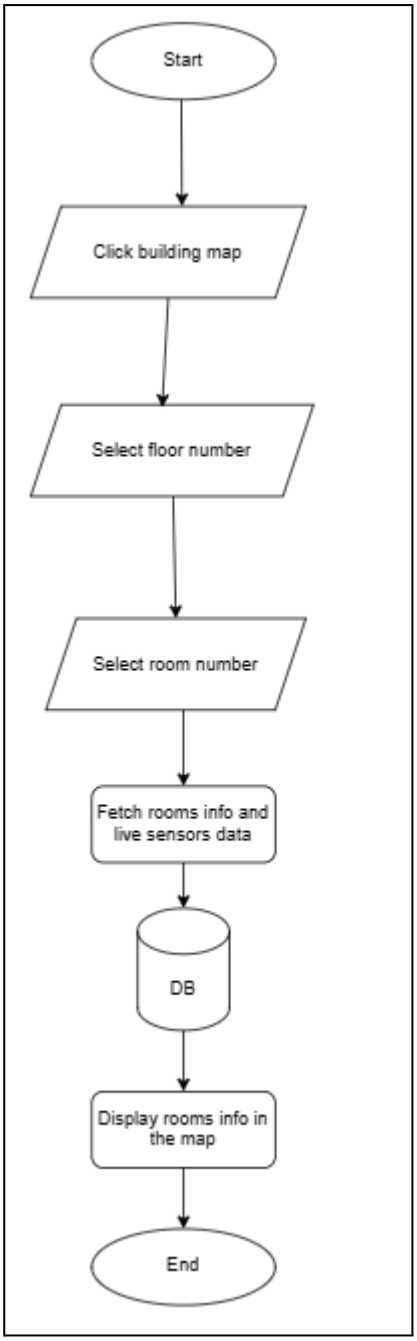


Figure 4.9 Interactive map flowchart

4.4 Data Design

4.4.1 Data Models

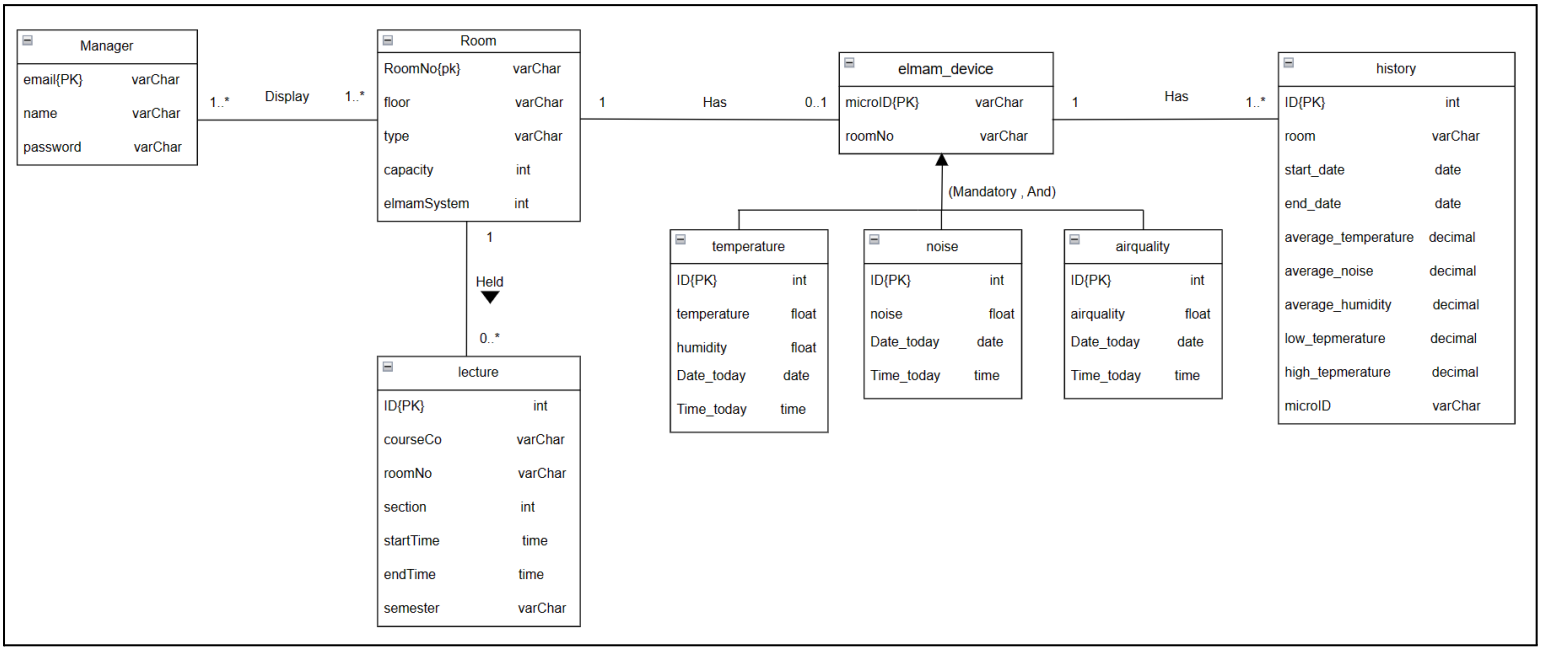


Figure 4.10 Elmam system ER

- The relational schema

Manager(email ,name , password)
Primary key Email

Room(roomNo , floor , type , capacity ,elmamSystem)
Primary key roomNo

Elmam_Device(microID , roomNo)
Primary key microID
Foreign key roomNo references Room (roomNo)

Lecture(ID, courseCo ,roomNo , section ,day , startTime, endTime, semester)
Primary key ID
Foreign key roomNo references Room (roomNo)

Temperature (id, temperature, humidity, microID, Date_today, Time_today)
Primary key id
Foreign key microID references Elmam_Device(microID)

Noise (id, noise, microID, Date_today, Time_today)
Primary key id
Foreign key microID references Elmam_Device(microID)

Airquality (id, airquality , microID, Date_today, Time_today)
Primary key id
Foreign key microID references Elmam_Device(microID)

Alerts (id, time, date, room, notification)
Primary key id

History (id, room, start_date, end_date, average_temperature, average_humidity, avrage_noise, low_temperature, high_temperature, microID)
Primary key id
Foreign key microID references Elmam_Device(microID)

- The data dictionary

Entity name	Attribute	Description	Data type	Length	Primary key	Foreign Key
Manager	email	The email of the manager.	String	40	yes	—
	name	The name of the manager.	String	25	—	—
	Password	The password of the manager account.	Varchar	50	—	—
Room	roomNo	The number of the room in which each room has a unique Id number.	String	10	yes	yes
	floor	The floor that the room is in.	int	15	—	—
	type	The type of the room.	String	25	—	—
	capacity	The capacity of the room.	int	4	—	—
	elmamSystem	To know if this room has a sensor or not.	boolean	2	—	—
Elmam_ Device	microID	A Unique number for every sensor.	String	50	yes	yes

	roomNo	The number of the room.	int	10	yes	yes
Lecture	ID	auto increment number to be unique for every lecture	int	100	yes	—
	courseCo	The code of each course.	String	10	—	—
	section	The Section number of the course.	int	10	—	—
	startTime	The start time of the lecture.	String	6	—	—
	endTime	The end time of the lecture.	String	6	—	—
	day	The day	String	15	—	—
	semester	The semester were if the first or the second semester	String	15	—	—
temperature	ID	A unique number for every storing row	int	11	yes	—
	temperature	The reading of the temperature.	float	—	—	—
	humidity	The reading of the humidity.	double	—	—	—

	microID	A Unique number for every sensor.	String	50	—	yes
	Date_today	The date of the day	date	—	—	—
	Time_today	The time of the day	time	—	—	—
noise	ID	A unique number for every storing row	int	11	yes	—
	noise	The reading of the noise.	float	—	—	—
	Date_today	The date of the day	date	—	—	—
	Time_today	The time of the day	time	—	—	—
	microID	A Unique number for every sensor.	String	50	—	yes
airquality	ID	A unique number for every storing row	int	11	yes	—
	airquality	The reading of the air quality .	float	—	—	—
	Date_today	The date of the day	date	—	—	—

	Time_today	The time of the day	time	—	—	—
	microID	A Unique number for every sensor.	String	50	—	yes
alerts	ID	auto increment number to be unique for every lecture.	int	100	yes	—
	time	The time of the alert	time	—	—	—
	date	The date of the alert	date	—	—	—
	room	The room number that has the alert	String	10	—	—
	notification	The text of the notification	text	—	—	—
history	ID	auto increment number to be unique for every report	int	100	yes	—
	room	The room number that report	String	10	—	—
	start_date	The start date of the report	date	—	—	—

	end_date	The end date of the report	date	—	—	—
	average_temperature	Average temperature in 5 days	decimal(5,2)	—	—	—
	average_humidity	Average humidity in 5 days	decimal(5,2)	—	—	—
	avrage_noise	Average noise in 5 days	decimal(5,2)	—	—	—
	low_temperature	The lowest temperature.	decimal(5,2)	—	—	—
	high_temperature	The highest temperature	decimal(5,2)	—	—	—
	microID	A Unique number for every sensor.	String	50	yes	yes

Table 4.3 Data dictionary

4.4.2 Data Collection and Preparation

Our system depends on collecting data from several external sources. First, we collected some data about the classrooms in the building of the College of Computing at King Saud University. You can find the data in Appendix C: Data collected.
Second, we collect data from three different sensors (temperature/humidity, air quality, and noise). We use ESP 8266 to connect the three sensors and extract the results.
Where in sprint-2 we upload the data to the cloud called Thingspeak. It is an Internet of Things analytics service that allows us to aggregate, visualize, and analyze live data streams. To connect our device to communicate with ThingSpeak, it must support HTTP or MQTT protocols.

During Sprint-4, we collected various live data from the indoor environment of room G09 in the College of Computer and Information Science. Subsequently, we directly stored this data in our database. This dataset proves instrumental in conducting various testing tasks.

4.5 Interface Design

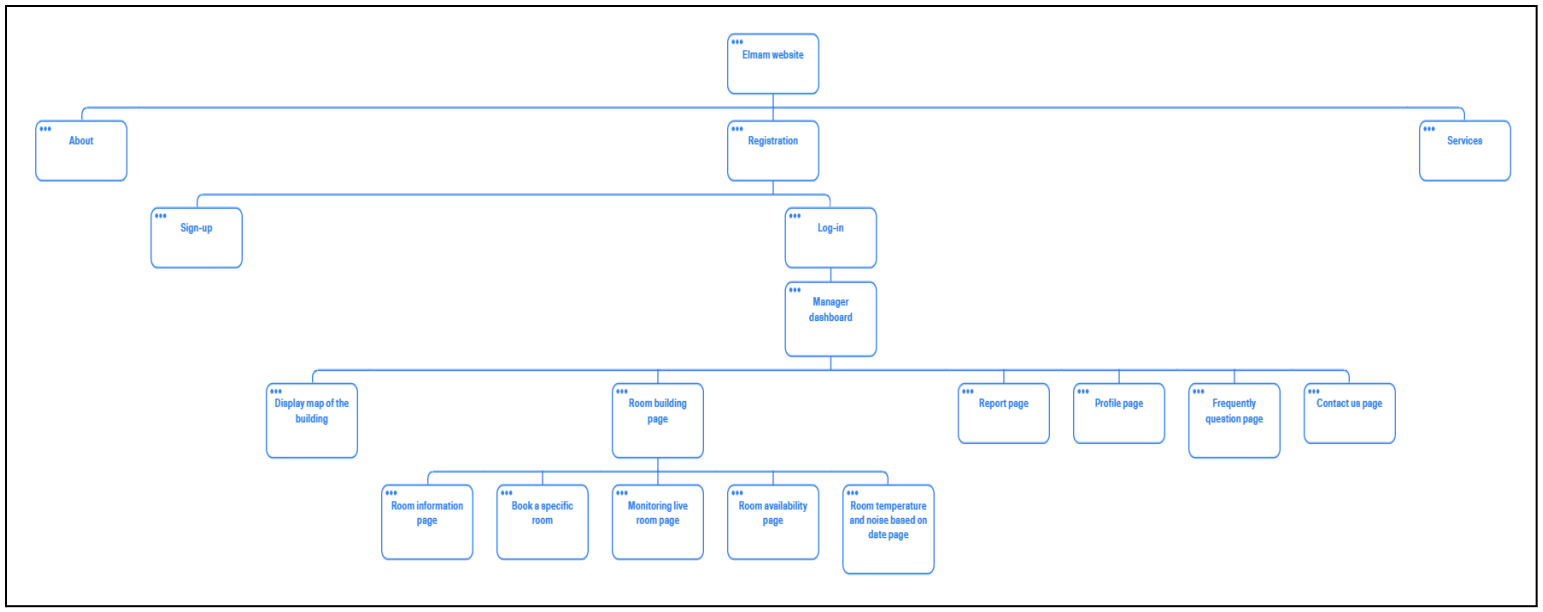


Figure 4.11 Site map

Elmam website User interfaces are built based on design rules, as these rules aid in the design of a user-friendly and increase its usability.

User experience guidelines:

- **Predictability:** means that interaction design should set accurate expectations about what will happen – before the user taps [13].
  As shown in figure 4.12 that displays the Elmam interface, the button text "التالي" indicates exactly the future action associated with it.

Figure 4.12 Predictability

- **Consistency** : when all the design elements behave similarly or follow the universally set pattern [14].
  As we used the same color on all pages and made all buttons on all pages look the same, and also made sure every component of our system behaves in a way that most users will expect it to behave as shown in figure 4.13.

Figure 4.13 Consistency

- **Familiarity** : It is the feeling of familiarity that users get when they encounter something that is similar to something they have seen or used before [15].
  The icons in the sidebar as shown in figure 4.14 support the use of metaphors since they make it easier for users to learn how to use the website without having to go through a detailed tutorial.

Figure 4.14 Familiarity

- **Simplicity** : that means creating interfaces that are straightforward to navigate.
  As we designed our website to be easy to understand and interact with in that users don't need to read instructions to understand how to use it, they can navigate between pages easily from the home page as shown in figure 4.15.

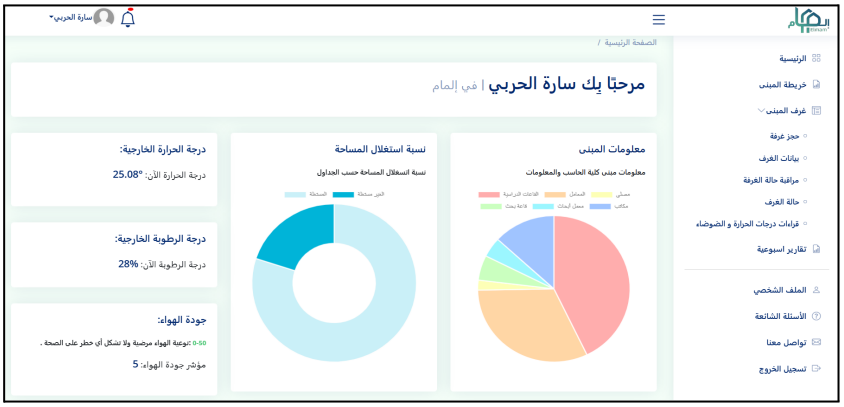


Figure 4.15 Simplicity

- **Generalizability** : is about extending specific interaction knowledge to new situations.
  As we designed the Log-in and sign-up page similar to many websites. So the user will be expected to know what he will do as shown in figure 4.16.

Figure 4.16 Generalizability

- **Useability** : Maximize user ability to go back to any previous point.
  As shown in figure 4.17 we add a button to let the user go back any time.

Figure 4.17 Useability

4.6 Implementation

In Sprint-2 of our development cycle, our team successfully completed work on the development of our system's software and hardware, including the website and the implementation of sensors. We focused on creating registration, login, and logout pages for building managers, as well as a main page where they could view a list of services provided by our system. These services include temperature, humidity, noise level, and air quality monitoring, along with a page displaying all available classes/rooms in the building, including their information such as name, type, capacity, and floor number.

Also, we initiated the integration of our three sensors, each with its unique functionality, with the ESP 8266 microprocessor (as shown in Figure 4.18). Through this integration, we successfully captured data from all three sensors. Subsequently, we utilized a WiFi interface to upload the collected data to our cloud platform, ThingSpeak. On ThingSpeak, the received data was processed and displayed in the form of graphs.

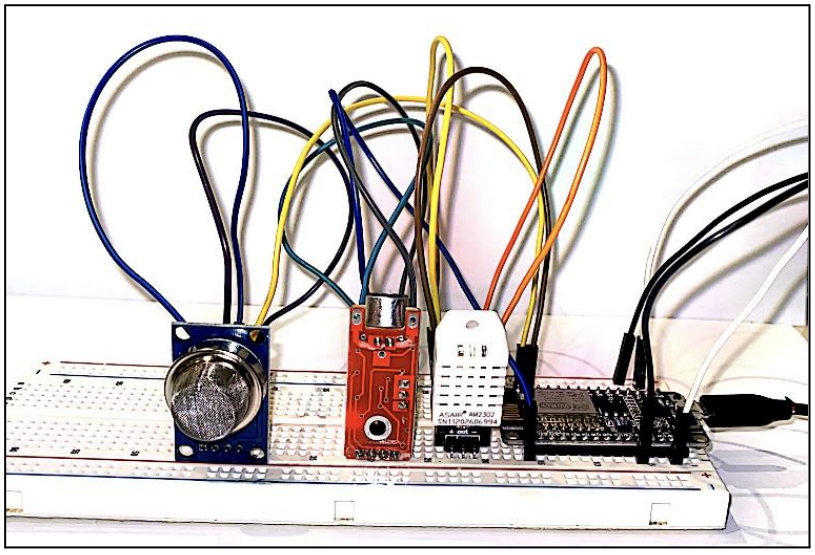


Figure 4.18 Sensors connecting to ESP

In Sprint-3, we stored various environmental parameters, such as temperature, humidity, air quality, and noise levels, from the processor into our designated database as shown in figure 4.19. To streamline this data transfer process, we established a connection between the sensor device and the database through the Internet. The data was transmitted to the database via HTTP requests, and it was systematically stored for subsequent utilization.

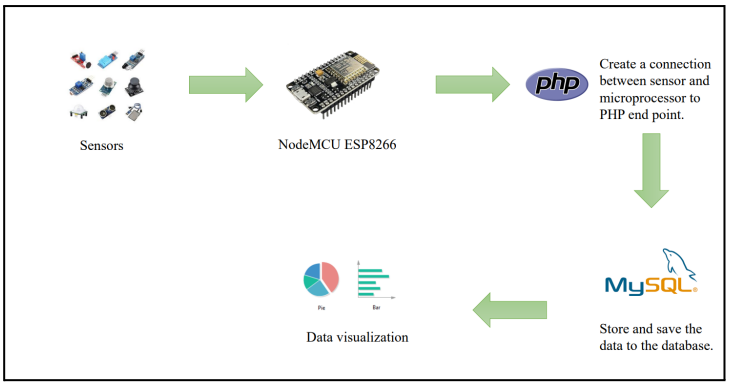


Figure 4.19 Storing live data to the database

In sprint-4 We started displaying all sensor data (temperature, humidity, noise, air quality) on the Elmam website. The building manager is now able to directly monitor the indoor environment by room. In addition, we have created weekly reports that the building manager can see to facilitate the process of making the necessary decisions in the building. We also worked on creating a special page to know the available rooms directly by time to reduce wasted space in halls and laboratories within the university. In addition, we have worked on an additional feature where the building manager can reserve a hall/laboratory/research hall according to the room number or capacity, and thus he can know whether the hall is available for reservation or not.

In Sprint-5, we conducted comprehensive testing of all system functionalities and successfully completed the hosting process.

- A link to our project's GitHub repository can be found [https://github.com/sara2alharbi/2023-GP1-2/tree/master].

4.7 Challenges

Our team encountered some difficulties with the recent release of our system due to the implementation of new hardware and sensors that we have not previously worked with. The system comprises three distinct sensor types, namely temperature, air quality, and noise sensors, each with unique operational mechanisms and varying communication methods. These sensors can either provide digital, analog, or both types of readings depending on the sensor. To manage these sensors and access their data, we connected them to an ESP 8266, a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capabilities. ESP 8266 contains one analog pin and 17 digital pins but we can only use 11 of them, because 6 pins are used to connect the flash memory chip(see figure 4.20).

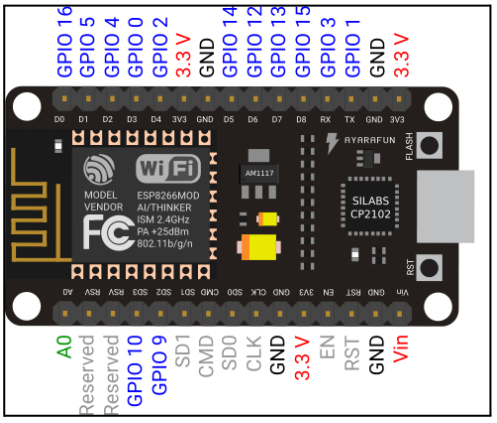


Figure 4.20 ESP8266 pins

In terms of software, we utilized XAMPP to host our system's web page.Which is a free and open-source web server solution that allows us to create a local web server environment on our computer. We can develop and test our websites and web applications without needing to upload files to a remote server. In addition, we use PHPMyAdmin as a database management tool for MySQL databases to store our data, including rooms and managers information.

To present the sensor data in graphical forms, we leveraged Thingspeak cloud, which is a cloud-based platform that allows us to collect, analyze, and visualize data from IoT devices. We establish the connection between IoT devices to ThingSpeak using the Messaging protocol. Then Thingspeak provided us with an API key to send our data in the cloud. However, we faced some challenges in connecting the sensors to Thingspeak due to network issues in the university. Despite these challenges, we were able to resolve the issues through connecting to 4G Wi-Fi but we still face some delay in representing the data.

Moreover, to enhance the functionality and aesthetics of our system, we customize the web page's design and layout, utilizing CSS , JavaScript ,PHP and we use C++ for sensor codes. We also utilized out-of-the-box components, such as Bootstrap, to improve the site's responsiveness and user experience. Throughout the development process, we consulted with students who had prior experience working with various sensors, leveraging their expertise to improve our system's overall performance and appearance.

During Sprint 3, our team encountered significant challenges related to data storage within our system's database. These challenges stemmed from the integration of two distinct devices, each equipped with a suite of sensors, including temperature sensors, noise sensors, air quality sensors, and microprocessors. When we attempted to store the collected data, we faced a critical issue: the data from both devices was being commingled, making it impossible to discern the origin of each data point. To overcome this obstacle, we devised a solution involving the assignment of unique identifiers to each device. These special numbers allowed us to precisely differentiate and attribute the stored data to its respective source device, thereby enabling efficient data management and analysis.

During Sprint-4, we face challenges in implementing the notification function due to the real-time nature of live sensor data. Synchronizing this data with the current time proved challenging, demanding a meticulous approach to ensure timely alerts, considering factors like time zones and data latency. To address these issues, we adopted a solution involving the establishment of specific time periods for notifications. This approach aimed to prevent an excessive number of notifications from disrupting the user's experience while navigating the site, enhancing overall user comfort.

5 System Evaluation

To evaluate the performance of the Elmam system, which has hardware and software components. We conducted experimental and user acceptance testing cases to ensure the validity, reliability and accuracy of our system.

5.1 Experimental Results

First, to validate the performance of our platform, which comprises three distinct sensors, we conducted individual assessments of each sensor's functionality. To test the temperature sensor, we bought a flame in close proximity to the sensor (see figure 5.1), and observed its response. Prior to exposing the sensor to the flame, the temperature reading was recorded as 24.40 degrees Celsius (see figure 5.2). Following exposure, the temperature reading increased to 26.40 degrees Celsius (see figure 5.3), confirming the proper operation of the temperature sensor. Therefore , since the relation between humidity and temperature is inversely proportional. When the temperature rises, the relative humidity decreases, resulting in a reduction of moisture content in the air. Conversely, when the temperature drops, the relative humidity increases, causing an increase in atmospheric moisture[18]. So , as we can see in figure 23 and 24 we have a correct reading for humidity also.

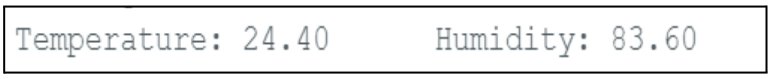


Figure 5.1 Temperature and humidity before

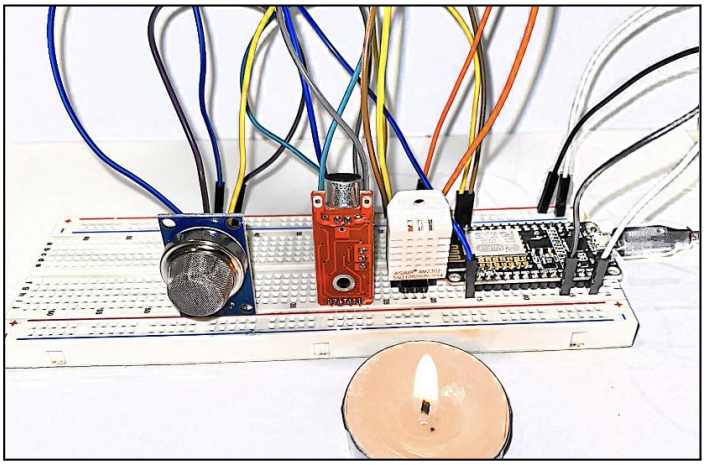


Figure 5.2 Sensor near to flame

Figure 5.3 Temperature and humidity after

For the sound sensor, we conducted an experiment to evaluate the performance. Specifically, we played two distinct lecture recordings over a 15-minute period in order to measure the sound rate. Our objective was to determine the sound level during a lecture in a specific hall. The first clip used in the experiment can be found here. Our findings indicate that the sound rate ranged from 23.55 to 25.03, with a frequency peak at 24.49(see figure 5.4). These results provide valuable insight into the acoustic conditions of the lecture hall, enabling us to make informed decisions regarding the suitability of the environment for academic activities.

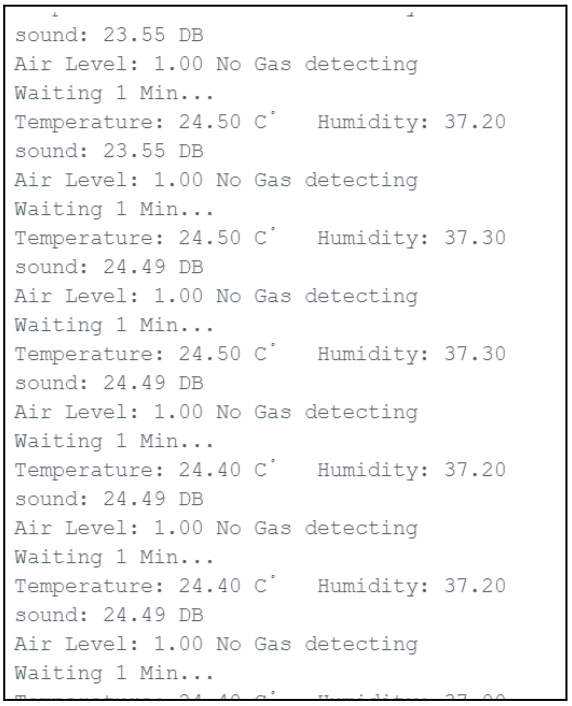


Figure 5.4 Sound in the first lecture

In addition to the first clip, we also tested the sound sensor using a second video, which can be found here. During the 15-minute test, the sound rate fluctuated between 23.42 and 24.68, with a frequency peak at 23.42 (see figure 5.5). Based on these findings, we can estimate that the sound rate during a lecture in the hall will range between 23.42 and 25.03. However, it is important to note that this rate may vary depending on factors such as the pitch and volume of the lecturer's voice.

```
Waiting 1 Min...
Temperature: 23.40 C°   Humidity: 37.20
sound: 23.42 DB
Air Level: 1.00 No Gas detecting
Waiting 1 Min...
Temperature: 23.30 C°   Humidity: 37.20
sound: 23.42 DB
Air Level: 1.00 No Gas detecting
Waiting 1 Min...
Temperature: 23.30 C°   Humidity: 37.10
sound: 23.42 DB
Air Level: 1.00 No Gas detecting
Waiting 1 Min...
Temperature: 23.30 C°   Humidity: 37.10
sound: 24.07 DB
Air Level: 1.00 No Gas detecting
Waiting 1 Min...
Temperature: 23.20 C°   Humidity: 37.00
sound: 24.35 DB
Air Level: 1.00 No Gas detecting
Waiting 1 Min...
Temperature: 23.10 C°   Humidity: 36.90
sound: 24.35 DB
Air Level: 1.00 No Gas detecting
```

Figure 5.5 Sound in the second lecture

Also, we noted that the measured rate of sound detection in a room without ambient noise fell within a range of 21.31 to 22.14, with a mode of 21.31 being the most frequently observed value (see figure 5.6). It is important to note that these measurements were taken in the presence of the air conditioning system's noise. As a result, it is reasonable to assume that a decrease in the rate of sound detection may occur in rooms where there is an absence of ambient noise.

These results provide valuable information for improving the space utilization of the lecture hall, and we can know about the hall if it is empty or has a class.

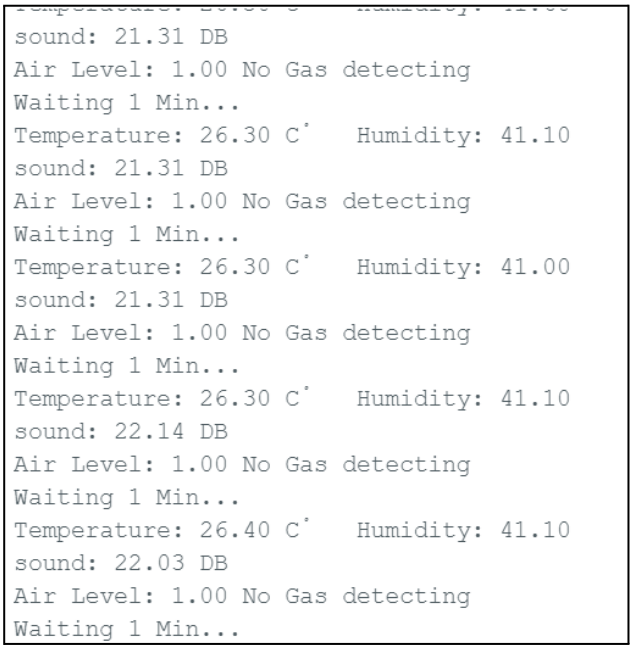


Figure 5.6 Sound in quiet room

Lastly, we tested the air sensor, which is designed to detect propane, methane, smoke, and alcohol. Specifically, we tested the sensor's ability to detect alcohol. Upon exposing the sensor to alcohol, the recorded reading became zero (see figure 5.8) , indicating the presence of one of the targeted substances. Conversely, a reading of one indicates the absence of any detected substance (see figure 5.7) , as the air sensor provides a digital readout.

```
Air Level: 1.00
No Gas detecting
Waiting 1 Min...
```

Figure 5.7 air_quality before

```
Air Level: 0.00
Some of Butane, Propane, Methane, Alcohol or Smoke was detecting
Waiting 1 Min...
```

Figure.5.8 air_quality after

Through these comprehensive tests, we were able to confirm the proper functionality of each sensor, thereby ensuring the accuracy and reliability of our system.

Note: all measure units for sound in decibel.

5.2 User Acceptance Testing

In this section, user acceptance testing is performed and documented, the testing evaluates the tasks shown in Table 5.1 of the second release of Elmam system to check if it satisfies the requirements.

Twenty end users participated, some of them are building managers who meet the project users' criteria. A questionnaire that consists of 10 questions that covers the system's interface, functionality and easiness was created to be answered by the participants at the end of the testing phase.

The participants completed the testing by performing the listed tasks in table 5.1, and responding to the questionnaire to evaluate the system, for questionnaire (see Appendix B).

Task number	Task	Maximum time done this task	Minimum time done this task
1	Registration	6.5ms	14.71ms
2	Log-in	3ms	8.40ms
3	View an interactive map of the building	1.50ms	3ms
4	Search for a specific room information in the interactive map	1.20ms	2.80ms
5	View the indoor environment of a specific room	3.11ms	7.28
6	View the temperature and noise data for specific room in specific date	3ms	4.60ms
7	View a statistical report for a specific room	4ms	4.80ms
8	View the availability of the room based on the schedule and noise sensor	1.81ms	4.40ms
9	Check if there any potential problem based on notifications	2ms	2.40ms
10	Book a specific room using room number	10.60ms	13ms
11	Book a specific room using capacity	10ms	15.50ms
12	Search for a specific room information	2ms	3.23ms
13	Log-out	1.33ms	2.26ms

Table 5.1 UAT Testing task

5.2.1 Demographics of Participants

The table 5.2 describes the end users who tested in Elmam system. These participants are interested in solutions that can help them monitor and optimize their building's environmental conditions.

Participants	Gender	Age	Building manager	Education level	Technical experience (Beginner, advanced, professional)
1	Female	24	Yes	Bachelor's	Advanced
2	Female	28	Yes	Bachelor's	Advanced
3	Male	33	Yes	Bachelor's	Professional
4	Female	38	Yes	Bachelor's	Advanced
5	Male	32	Yes	Master	Professional
6	Female	23	Yes	Bachelor's	Professional
7	Male	40	Yes	Master	Professional
8	Female	45	Yes	Master	Professional
9	Female	30	Yes	Bachelor's	Professional
10	Male	42	Yes	Master	Professional
11	Female	30	Yes	Bachelor's	Advanced
12	Female	27	Yes	Bachelor's	Advanced
13	Female	33	Yes	Bachelor's	Advanced
14	Female	42	Yes	Bachelor's	Advanced
15	Female	28	Yes	Bachelor's	Advanced
16	Female	31	Yes	Bachelor's	Advanced

17	Male	36	Yes	Bachelor's	Professional
18	Male	33	Yes	Bachelor's	Advanced
19	Female	30	Yes	Bachelor's	Advanced
20	Female	34	Yes	Bachelor's	Advanced

Table 5.2 Demographic table

5.2.2 Questionnaire/Interview Results

After the testing, each participant answered the questionnaire that consisted of 10 questions to evaluate the system. The table 5.3 summarizes the results of the questionnaire, and for questionnaire charts (see Appendix B).

Question number	Questions	Answers
1	وجدت أن النظام كان سهل الاستخدام.	نعم :100% لا: 0 نوعا ما :0
2	كان الموقع واضحًا وله ألوان جميلة وكان مريحًا للعيون.	نعم :100% لا: 0 نوعا ما :0
3	عملت جميع المهام في الموقع بشكل جيد.	نعم :95% لا: 0 نوعا ما : 5%
4	لقد وجدت أنه من السهل التنقل عبر الصفحات.	نعم : 100% لا: 0 نوعا ما :0
5	كانت رسائل الخطأ واضحة بالنسبة لي.	نعم :90% لا: 0 نوعا ما :10%
6	لقد وجدت أن النظام يحتاج الى مساعدة من خبير تقني لاستخدام الموقع.	نعم :0 لا: 90% نوعا ما :10%
7	ماهي الخدمات التي لم تكن واضحة الاستخدام في الموقع؟	1. لا يوجد 2. لايوجد 3. لايوجد 4. جميع الخدمات واضحة 5. جميع الخدمات كانت واضحة بشكل ممتاز بالنسبة لي. 6. في صفحة حالة الغرفة ، اضافة عمودين لل (الجدول الدراسي و الضوضاء) قد يشكل صعوبة بالفهم قليلا أعتقد من الأفضل أن يكون

هناك عمود واحد يدمج بين هاتين الميزتين ويتم عرضها مباشرة لي. 7. كانت الخدمات جميعها واضحة وسهلة الاستخدام 8. جميعها كانت واضحة 9. جميعها واضحة 10. كل الخدمات كانت واضحة وسهلة الاستخدام 11. جميعها واضحة 12. كانت واضحه جدا 13. لايوجد, سهلة الاستخدام من أول تجربة 14. سهل الاستخدام 15. عملت جميعها 16. واضحة جدا جميع الخدمات وسهل التنقل 17. واضح 18. جميع الخدمات رائعة وممتازة عملت بالشكل المطلوب 19. يفضل إضافة خدمة تحكم من ضمن خدمة المراقبة للبيئة الداخلية للغرفة 20. جميع الخدمات عملت بطريقة صحيحة		
نعم :90% لا: 0 نوعا ما :10%	لقد وجدت أن النظام يلبي احتياجاتي.	8
نعم :100% لا: 0 نوعا ما :0	كان الأداء العام للموقع مرضيا.	9
1. في صفحة عرض الخريطة اقترح أن تكون بحجم أصغر حتى استطيع رؤية جميع الغرف من النظرة	شارك/ي اقتراحاتك وملاحظاتك حول النظام.	10

الأولى. بالتوفيق 2. فكرة جميلة ونظام ممتاز بالتوفيق 3. اقترح ان يكونون الطلاب او زوار المبنى قادرين على استخدام النظام ، حيث في حال تأثر أحد الزوار في غرفة معينة يتم رفع طلب من خلال زوار المبنى في الغرفة لحل المشكلة من قبل مدير المبنى بشكل أسرع. 4. نظام جميل ، يفضل ان يكون حل المشاكل المتعلقة بدرجة الحرارة و الهواء تلقائيا من النظام دون تدخل مدير المبنى. 5. نظام رائع جدا 6. اقترح باضافة مستشعرات للجهاز 7. لا يوجد جميعها ممتازه 8. نظام جميل ويخدم احتياجات مديري المباني لكن اتمنى انه يتوسع بحيث يربط أكثر من مبنى 9. جميع المهام لبت احتياجاتي في إدارة المبنى بشكل جيد وفعال 10. اقترح بالتوسع و بوضع هذه المستشعرات في الاسياب ونقاط التجمع في المبنى والبهو بحيث يكون اداره المبنى شامل في كل شي 11. الفكرة جميلة والموقع عكسها بشكل رائع موفقين 12. لا يوجد		

13. النظام متكامل ويساعدنا كمدراء مباني بشكل كبير 14. جميل وتستحقون براءة اختراع بوركتم 15. الله يوفقكم وممكن يكون فيه حساسات اخرى مساعدة مستقبلا 16. موفقين 17. فكرة مفيدة ومساعدة وبامكانكم اضافة بعض التقنيات مثل AI 18. نظام رائع كل التوفيق 19. تطوير النظام ليصبح ليس موقع فقط بل أيضا تطبيق على الهواتف المحمولة 20. فكرة جميلة جدا كل التوفيق		

Table 5.3 Testing Question

5.3 Quality Attributes (NFR testing)

While testing the system we took into consideration the non-functional requirements. We tested each requirement based on its measurement as shown below in table 5.4.

User story	Quality Attribute	Measure	Results
As a user of Elmam website , **I want** the website to process any request within less than 4 seconds **So that** I don't get irritated.	(Performance) How responsive is the system and its components?	Compute the response time for displaying the website pages. Pages need at most 10 seconds to be fully displayed.	• First we do hosting for our system. • Then calculate the time the pages take to be displayed. • The minimum time was (1.08 second)for displaying all room, maximum time was (6.51 second) for booking specific room, and the average time for displaying all task pages was (21.7 second)
As a user of the Elmam system, **I want** my account to be secured **So that** it can be protected from unauthorized access.	(Security) How secure are the credentials and the accounts?	• Check the error message of failed Log-in attempts. • The password must be at least 8 characters or numbers and stored hashed. • The error message of failed Log-in attempts must not provide any specific information.	• First, we let the users create an account at the beginning of the test. Then validate the password requirements after the user enters a good password and check the type of the password stored in the

			database that should be hashed. • Second, we let the users Log-in with wrong credentials and check the error message.
As a building manager, **I want** the website to be available 99 % when I try to use it **so that** I don't become upset and switch to another site.	(Availability) What is the percentage of time that the app is up and running without any downtime or errors.	Track the uptime (the amount of time the app is accessible and functioning as intended) of the website. The website needs to be available 99% of the time.	During testing the website with the users, we tracked the uptime of the website. Website was available 99% of the time.

Table 5.4 NFR Testing

5.4 Discussion

This section provides an interpretation of the results obtained from system evaluation and user feedback and responses (you can find the result in APPENDIX B). From the user acceptance test and questionnaire, we can say that the design and interface of Elmam is clear and easy to interpret by building managers without needing support or learning a lot of things. The main functions of the website such as the registration process, room reservation, display of live sensor data, interactive map,display air quality and temperature based on specific date and report are well integrated and consistent, and navigation between these functions and their different interfaces is properly implemented and represented.

However, one user provided feedback during testing, explaining that the room data displayed on the map is too large, making other room information not clearly visible. In response, we've considered this feedback and implemented adjustments to reduce the size of the information, making it easier to see all room details on the map.

Additionally, another user suggested that users should be able to control the indoor environment through the system, rather than just monitoring it. In response, we will be working on this feature in the future so that building managers can open/close windows when temperature or humidity is affected.

We also identified from the first NFR usability test that the time needed to display task pages was higher than expected. Upon researching similar websites, we found that displaying the site legibly once visible and identified would solve the problem, reducing the time it takes to understand and complete the process. As for the remaining NFRs, they have all been tested and functioned as required.

Some suggested additional features that we will be sure to add in the future include adding sensors and placing them at collection points, as well as developing the system into not only a website but also an app. This app won't require intervention from the building manager or visitors; the building will be able to use the system directly to address problems as they arise.

In conclusion, the overall results obtained from the system evaluation are positive based on the feedback and responses. Most modifications were not due to a lack of skills, debugging, or poor user experience but were seen as opportunities to improve the usability of the system. All testers praised the system and expressed their intention to use it if deployed, as it effectively solves real-life problems. Overall, feedback on our system has been positive, and we have considered previous feedback during the development and improvement process.

6 Conclusions and Future Work

This document presents a comprehensive overview of our journey with the Elmam system, starting with an introduction that outlines the challenges faced by building managers and the proposed solution to address these issues. The project goals, objectives, and scope have been established to provide a clear understanding of Elmam.

Following the introduction, we conducted a background and literature review to gain a deeper understanding of Elmam. This review included a brief explanation of knowledge aspects used in Elmam, such as Recommender Systems, and research on similar systems in the market to identify their strengths and weaknesses. This information helped us to develop a system that stands out among competitors, fills the market gap, and includes the necessary features.

Next, we provided a system description to understand the system users and the decomposition of individual parts working together to support the understanding of the main components of Elmam features that will be implemented. The data design and user interface were then presented in detail.

- ## Global and local impact

  The problem is that many building managers cannot monitor the building well enough to provide a comfortable indoor environment. All because there is no complete and effective building control system. Elmam solves this problem by developing a system that helps in facilitating the process of monitoring and controlling buildings without invading privacy. Through this system, it will help the managers of the building to provide a comfortable and effective environment, and control it remotely without the need to enter data manually. Elmam will also help and facilitate the process of monitoring air quality, noise and temperature through sensors .

- ## Problems and challenges encountered during the software development

  Not surprisingly our journey of developing Elmam had some difficulties along the way, we first encountered some difficulties in understanding the requirements and which information was necessary to gather from building managers, but after conducting many interviews and questionnaires we had a better understanding of the requirements. also faced difficulties while implementing as we tried to have an easy UI and consistent between all the pages to provide our users with the best user experience. But mostly our biggest challenge was developing our website using new devices and sensors since we encountered many errors while choosing the good database and connecting it and retrieving the data , but we overcame that by researching the errors we faced and trying to solve it together.

- Limitations of the system

  While the system showcases numerous strengths, it is important to recognize certain limitations. Ongoing maintenance requirements, such as sensor calibration and software updates, highlight the need for continuous system upkeep. The system's functionality relies on a stable power supply, making it susceptible to interruptions during power outages. Finally, adherence to regulatory standards, particularly concerning data privacy and environmental monitoring, imposes an enduring responsibility. Effectively addressing these limitations is imperative for refining the system's design, ensuring its adaptability, and enhancing its effectiveness across diverse operational contexts.

- The main contribution of the project

  Elmam aims at making monitoring the building easier by providing a system that helps building managers to control and monitor the building with less effort and time-consuming for building managers.

  The first release of the Elmam system was focused on the building manager's side to allow the building manager's to create an account in the website, show live stream sensor data ,display (temperature/humidity/air quality/noise) and display a list of all the rooms in the building. The second release of Elmam system, which is the final release continued with building manager's to allow him/her to report an alert if there is a potential problem,display temperature , air quality and noise based on the room, display or download a weekly report feature that summarizes building statistics,display a temperature during a specific time, finally display room occupied or available.

- Future work

Moving forward, our team is dedicated to enhancing the functionality of our system by implementing several new features. The Elmam system team will continue to expand and work tirelessly to make the system better. Our ongoing efforts involve developing the system to extend its availability beyond educational institutions to government facilities, hospitals, and other public buildings. As part of this expansion, we aim to address environmental challenges, such as temperature and humidity fluctuations, by incorporating functionalities like automatically opening windows when the humidity or temperature rises inside a room. Additionally, we're working on connecting the system to screens located outside each room, providing building visitors with easy access to real-time information about the room's internal environment without having to enter it. These developments underscore our commitment to advancing the Elmam system's capabilities and broadening its application across diverse settings.

7 Acknowledgements

We thank Allah for everything, we would not be able to carry out this project without the strength that was given to us. There are no words to express our deepest thanks and gratitude to our supervisor Dr. Nailah Alhassoun for her assistance, encouragement, support and precious advice. Also, we gratefully acknowledge our scrum master Dr.maha Alyahya for her guidance and support. We would like to acknowledge the College of Computer and Information Sciences at King Saud University, particularly the Information Technology department, for providing us with an excellent learning environment and resources. Finally, we want to express our deepest gratitude and appreciation to our family and friends for their love, support, and encouragement throughout this journey. Without their kindness and encouragement, we would not have been able to accomplish this project successfully.

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9 Appendix

9.1 APPENDIX A: Planned Interview questions

Planned Interview	
Questions 1: What are your tasks as a "building manager"? For each task: How would you like to make that task easier to finish better/faster?	**السؤال الأول:** ماهي المهام التي تقومين بها ك"مديرة للمبنى"؟ لكل مهمة: كيف ترغبين تسهيل تلك المهمة لإنهائها بشكل أفضل/بوقت أسرع؟
Questions 2: What are the biggest problems and challenges that you faced during the process of managing the building?	**السؤال الثاني:** ماهي أكبر المشاكل أو التحديات التي واجهتك أثناء عملية إدارتك للمبنى؟
Questions 3: Have you received complaints in one of the buildings that you managed, and if the answer is yes, what do you think is the reason for those complaints?	**السؤال الثالث:** هل تلقيت شكاوى في احد المباني التي قمت بإدارتها ، في حال كانت الإجابة بنعم ، برأيك ما سبب تلك الشكاوي؟
Questions 4: Do you find it difficult to manage the rooms in the building? In your opinion, what is the reason for the difficulties you face?	**السؤال الرابع:** هل تواجهين صعوبة بإدارة الغرف في المبنى؟ من وجهة نظرك ما سبب تلك الصعوبات التي تواجهينها؟
Questions 5: Does the entry of students at other than specified times affect your tasks? How can it affect?	**السؤال الخامس:** هل دخول الطالبات إلى المعمل/القاعة في غير الأوقات المحددة يؤثر على مهامك؟ كيف ممكن يؤثر؟

Questions 6: Does the air quality of the place affect your tasks? How is the impact?	**السؤال السادس:** هل جودة الهواء في المكان تؤثر على مهامك؟كيف يكون التأثير؟
Questions 7: Does the temperature in the place affect your tasks? How is the effect?	**السؤال السابع:** هل درجة الحرارة في المكان تؤثر على مهامك؟كيف يكون التأثير؟
Questions 8: Does knowing that the hall/lab is busy at the scheduled time help you in some of your tasks? How can that help you?	**السؤال الثامن:** هل معرفتك بإن القاعة/المعمل مشغول في الوقت المجدول يساعدك في بعض مهامك؟كيف ممكن يساعدك ذلك؟
Questions 9: Have you used a building management system before? If yes, what did you like about this system in particular? And what are the shortcomings that you found in this system?	**السؤال التاسع:** هل استخدمتي نظام لإدارة المباني من قبل؟ اذا كانت الاجابة بنعم ، فما الذي أعجبك في هذا النظام تحديدًا؟ و ماهي هي العيوب التي وجدتها في هذا النظام؟
Questions 10: In the event of creating a system that helps you in the building management process, what are the features and services that you would like to be provided by the system?	**السؤال العاشر:** في حال إنشاء نظام يساعدك في عملية إدارة المبنى ماهي المميزات والخدمات التي ترغبين توفرها بالنظام؟
Questions 11: In your opinion, what information should be available in a building management system to help building managers?	**السؤال الحادي عشر:** برأيك ما هي المعلومات التي يجب توفرها في نظام إدارة المباني لمساعدة مديري مبنى؟
Questions 12: In your opinion, how can the quality of the internal environment of the building be improved using modern technologies?	**السؤال الثاني عشر:** برأيك كيف يمكن تحسين جودة البيئة الداخلية للمبنى باستخدام التقنيات الحديثة؟

Interview outline	
Interview #1	
Interviewee: Layla Alharbi	**Interviewer:** Sara Alharbi
Location : WhatsApp Chat	**Date**: 7\4\2023 **Start Time**: 10:00PM **End Time**: 10:33PM

Objectives:

- Gain ideas about what building managers dislike in other building management systems .
- Gathering information about the features that users want available in our system.
- Collecting information about what is difficult for building managers while managing the building .

Reminders:

- The interviewee is a school manager.

  The interviewee's age is 42.

Agenda:
Approximate Time:

- **Introduction**	**3 min**
- **Background on system**	**5 min**
- **Overview of interview**	**2 min**
- **Interview questions**	**20 min**
- **Closing**	**3 min**

General Observations: The Interviewee was cooaprative.

Topics not covered: none

السؤال	الإجابة
السؤال الأول: ماهي المهام التي تقومين بها ك"مديرة للمبنى"؟ لكل مهمة: كيف ترغبين تسهيل تلك المهمة لإنهائها بشكل أفضل/بوقت أسرع؟	كوني مديرة مدرسة ، فأنا مسؤولة عن عدة مهام من أبرزها ،التخطيط والقيام بالصيانة الدورية للمبنى، إدارة خدمات التكييف،ضمان وجود أمني دائم وعدة مهام أخرى. في الحقيقة أرغب بوجود تطبيق يضم لي جميع ماذكرته سابق في واجهة مستخدم واحدة حيث أستطيع التحكم ومراقبتها جميعا عن بعد.
السؤال الثاني: ماهي أكبر المشاكل أو التحديات التي واجهتك أثناء عملية إدارتك للمبنى؟	أبرز التحديات التي واجهتها هي ضبط التكاليف الصيانة والأعطال حسب الميزانية المحددة ، لأن في الغالب تكون ميزانية الصيانة عالية جدًا والميزانية المحددة للمدرسة لاتكفي لذلك.فعند وجود إدارة ممتازة وتخدمني أستطيع إدارة المبنى بشكل أسهل وتخفيف من تكاليف الصيانة.
السؤال الثالث: هل تلقيت شكاوى في احد المباني التي قمت بإدارتها ، في حال كانت الإجابة بنعم ، برأيك ما سبب تلك الشكاوي؟	نعم تلقيت بعض الشكاوى من أولياء الأمور بخصوص الرائحة في الممرات الخاصة بالمدرسة ، ولذلك أعتقد أننا بحاجة إلى ماينقي لنا الهواء ويكشف لنا عن تلك الروائح.

السؤال الرابع: هل تواجهين صعوبة بإدارة الغرف في المبنى؟ من وجهة نظرك ما سبب تلك الصعوبات التي تواجهينها؟	نعم، تكمن صعوبتي في عدم توفر ما يساعدني لذلك ، سواء تطبيق بالجوال أو أجهزة تساعد على إدارة المبنى بشكل أسهل.
السؤال الخامس: هل دخول الطالبات إلى المعمل/القاعة في غير الأوقات المحددة يؤثر على مهامك؟ كيف ممكن يؤثر؟	غالبا كوني مديرة للمدرسة لايؤثر علي ، ولكن بالطبع يؤثر على الأدوات الخاصة بالمدرسة خاصة في المعامل ، قد يستخدمها الطالبات وتؤثر على المبنى.
السؤال السادس: هل جودة الهواء في المكان تؤثر على مهامك؟كيف يكون التأثير؟	نعم تؤثر ، لا تؤثر علي فقط بل تؤثر أيضا على الطالبات في الفصول مما يسبب لهم عدم الراحة وعدم التركيز في المناهج الدراسية. يكون التأثير عند تلوث الهواء ، مثلا عند جوث غبار ف يجب تنظيف الفصول والمعامل بشكل مستمر خاصة الطالبات المصابين بالربو يتأثرون.أيضا أحيانا يتم استخدام بعض الغازات التي لها رائحة في المعامل مما يؤثر ذلك على بعض الطالبات.
السؤال السابع: هل درجة الحرارة في المكان تؤثر على مهامك؟كيف يكون التأثير؟	نعم تؤثر، عندما تكون درجة الحرارة داخل غرفة صغيرة حارة جدا و مكتومة عندها لا أستطيع تنفيذ مهامي بدقة ، غير أنها ممكن أن تكون مصدر للأمراض لأنها مكان صغير ومكتوم .
السؤال الثامن: هل معرفتك بإن القاعة/المعمل مشغول في الوقت المجدول يساعدك في بعض مهامك؟كيف ممكن يساعدك ذلك؟	نعم ، أعتقد لك سيساعد الوكيلة في معرفة ما إذا بإمكانها جدولة الفصل الفارغ ووضع فيه حصة النشاط .
السؤال التاسع: هل استخدمتي نظام لإدارة المباني من قبل؟ اذا كانت الاجابة بنعم ، فما الذي أعجبك في هذا النظام تحديدًا؟ و ماهي هي العيوب التي وجدتها في هذا النظام؟	لا لم أستخدم.

السؤال العاشر: في حال إنشاء نظام يساعدك في عملية إدارة المبنى ماهي المميزات والخدمات التي ترغبين توفرها بالنظام؟	أرغب بتوفير خدمة الإشعارات الذاتية ، حيث لو لا سمح الله قد يحصل حريق أو تم استعمال أحد الغازات في المعامل ، أحصل على إشعار مسبق في هاتفي لتفادي الضرر.
السؤال الحادي عشر: برأيك ما هي المعلومات التي يجب توفرها في نظام إدارة المباني لمساعدة مديري مبنى؟	أعتقد يجب أن يكون النظام مرتبط في الدفاع المدني ومراكز الصيانة ، حيث يكون لديهم معرفة كاملة عن المبنى ، يجب أن يحتوي النظام على أبرز وأهم الأشياء مثل: درجة الحرارة ، وصيانة الأجهزة ،إنذارات الحريق، وإنذارات المصاعد .
السؤال الثاني عشر: برأيك كيف يمكن تحسين جودة البيئة الداخلية للمبنى باستخدام التقنيات الحديثة؟	أعتقد نستطيع استخدام تقنيات الذكاء الإصطناعي حيث تمكنا من تنبؤ عند حصول أي ضرر لاسمح الله. وأيضًا استخدام الأبواب الذكية التي تتيح إمكانية فتح وإغلاق الأبواب بشكل تلقائي.

Interview outline	
Interview #2	
Interviewee: Hind Almutiri	**Interviewer:** Sara Alharbi
Location : WhatsApp Chat	**Date**: 7\4\2023 **Start Time**: 11:00PM **End Time**: 11:33PM

Objectives:

- Gain ideas about what building managers dislike in other building management systems .
- Gathering information about the features that users want available in our system.
- Collecting information about what is difficult for building managers while managing the building .

Reminders:

- The interviewee is a School manager.

  The interviewee's age is around 39.

Agenda:	**Approximate Time:**
- Introduction	**3 min**
- Background on system	**5 min**
- Overview of interview	**2 min**
- Interview questions	**20 min**
- Closing	**3 min**

General Observations: The Interviewee was cooaprative.

Topics not covered: none

السؤال	الإجابة
السؤال الأول: ماهي المهام التي تقومين بها ك"مديرة للمبنى"؟ لكل مهمة: كيف ترغبين تسهيل تلك المهمة لإنهائها بشكل أفضل/بوقت أسرع؟	أعمل كمديرة مدرسة، ومن مهامي الأساسية صيانة الدورية لأراضي المدرسة وكافة معداتها وضمان بقاء مرافق المدرسة آمنة

السؤال الثاني: ماهي أكبر المشاكل أو التحديات التي واجهتك أثناء عملية إدارتك للمبنى؟	أكثر المشاكل التي تتكرر هي مشكلات تتعلق بالجوانب المادية ، و الافتقار إلى المباني المدرسية والأجهزة الملائمة فضلا عن الصيانة المستمرة.
السؤال الثالث: هل تلقيت شكاوى في احد المباني التي قمت بإدارتها ، في حال كانت الإجابة بنعم ، برأيك ما سبب تلك الشكاوي؟	نعم ، تلقيت شكاوى بخصوص قلة الصيانة المتوفرة داخل الفصول ، حيث كثير من التكييفات تتعرض للعطل ، ويرجع ذلك إلى ضعف الصيانة الدورية.
السؤال الرابع: هل تواجهين صعوبة بإدارة الغرف في المبنى؟ من وجهة نظرك ما سبب تلك الصعوبات التي تواجهينها؟	نعم، أواجه صعوبة في الاستهلاك الطاقة يتطلب المبنى الكثير من الطاقة من خلال الإضاءة وتكييف الهواء والتدفئة، ويجب علينا تخصيص ميزانية وجهود للحد من الاستهلاك الطاقة وتوفير الكهرباء. يمكن أن يكون سبب هذه الصعوبات هو عدم تخصيص ميزانية كافية لإدارة المدرسة.
السؤال الخامس: هل دخول الطالبات إلى المعمل/القاعة في غير الأوقات المحددة يؤثر على مهامك؟ كيف ممكن يؤثر؟	نعم يؤثر ذلك على مهام مشرفي المعامل ، لأنهم يقومون بفتح المعمل عند الحاجة فقط.
السؤال السادس: هل جودة الهواء في المكان تؤثر على مهامك؟كيف يكون التأثير؟	نعم تؤثر ،لأن جودة الهواء المتدنية يمكن أن تسبب مشاكل صحية للأشخاص الذين يتواجدون في المبنى.من الممكن أن تؤثر هذه المشاكل الصحية على الأداء والتركيز والإنتاجية بشكل عام.
السؤال السابع: هل درجة الحرارة في المكان تؤثر على مهامك؟كيف يكون التأثير؟	نعم تؤثر ، لأن درجة الحرارة المرتفعة أو المنخفضة يمكن أن تسبب إزعاجاً وعدم راحة للأشخاص الذين يتواجدون في المدرسة.وقد يؤثر ذلك على قدرتي على إدارة المدرسة وتنفيذ مهامي بكفاءه.

السؤال الثامن: هل معرفتك بإن القاعة/المعمل مشغول في الوقت المجدول يساعدك في بعض مهامك؟كيف ممكن يساعدك ذلك؟	نعم ، يساعد ذلك في عملية تنظيم خطة المقترحة للفصل الدراسي .
السؤال التاسع: هل استخدمتي نظام لإدارة المباني من قبل؟ اذا كانت الاجابة بنعم ، فما الذي أعجبك في هذا النظام تحديدًا؟ و ماهي هي العيوب التي وجدتها في هذا النظام؟	لا لم أستخدم أنظمة من قبل.
السؤال العاشر: في حال إنشاء نظام يساعدك في عملية إدارة المبنى ماهي المميزات والخدمات التي ترغبين توفرها بالنظام؟	من أهم الخدمات التي أرغب أن تكون متوفرة: توفير وظيفة للإدارة المالية، حيث تمكن لي تتبع الميزانية والتقارير المالية وإدارة الفواتير والمدفوعات والإيرادات. أيضا توفير وظيفة إدارة الحجوزات، حيث يمكنني إدارة الحجوزات الفصول الدراسية والقاعات والمرافق الأخرى بسهولة.
السؤال الحادي عشر: برأيك ما هي المعلومات التي يجب توفرها في نظام إدارة المباني لمساعدة مديري مبنى؟	يجب أن يحتوي على معلومات عامة عن المبنى و ونسب خاصة لكل من الصيانة الدورية و الاعطال و الأجهزة المتوفرة وطرق التحكم فيها .
السؤال الثاني عشر: برأيك كيف يمكن تحسين جودة البيئة الداخلية للمبنى باستخدام التقنيات الحديثة؟	استخدام أنظمة التهوية الذكية و أنظمة الإضاءة الذكية التي تستشعر بوجود الأشخاص وبناء عليه تعمل.

Interview outline

Interview #3

Interviewee: Noura Alshehri **Interviewer: Joury Alasmari**

Location : online

Date: 10\4\2023

Start Time: 8:10PM

End Time: 8:43PM

Objectives:

- Gain ideas about what building managers dislike in other building management systems .
- Gathering information about the features that users want available in our system.
- Collecting information about what is difficult for building managers while managing the building .

Reminders:

- The interviewee is a building manager.

  The interviewee's age is 47.

Agenda:
Approximate Time:

- **Introduction** **3 min**
- **Background on system** **5 min**
- **Overview of interview** **2 min**
- **Interview questions** **20 min**

- Closing	**3 min**
General Observations: The Interviewee was cooaprative.	
Topics not covered: none	

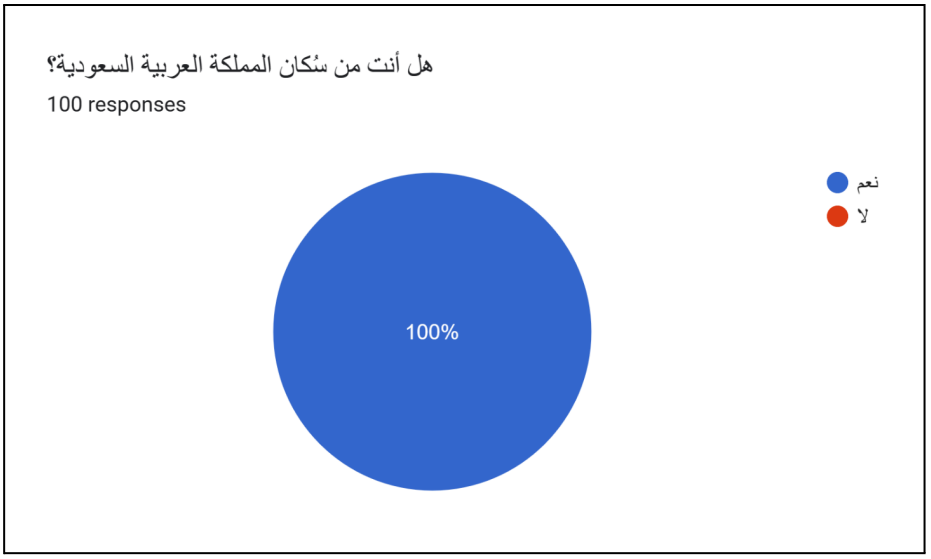
السؤال	الإجابة
السؤال الأول: ماهي المهام التي تقومين بها ك"مديرة للمبنى"؟ لكل مهمة: كيف ترغبين تسهيل تلك المهمة لإنهائها بشكل أفضل/بوقت أسرع؟	إدارة المبنى وملحقاته (الغرف) وجدولة الغرف مع توقيتها وأخذ جودة الهواء ودرجة الحرارة بعين الاعتبار حتى تسير العملية التعليمية بشكل جيد، بالتأكيد وجود التقنية سوف يساعد كثيرا في تحسين وحل المشاكل.
السؤال الثاني: ماهي أكبر المشاكل أو التحديات التي واجهتك أثناء عملية إدارتك للمبنى؟	ارضاء الحاضرين في كل غرفة للبيئة الداخلية.
السؤال الثالث: هل تلقيت شكاوى في احد المباني التي قمت بإدارتها ، في حال كانت الإجابة بنعم ، برأيك ما سبب تلك الشكاوي؟	نعم، شكاوى بخصوص درجة الحرارة(التكييف) وجودة الهواء لا تتناسب مع عدد الأشخاص بالغرفة.
السؤال الرابع: هل تواجهين صعوبة بإدارة الغرف في المبنى؟ من وجهة نظرك ما سبب تلك الصعوبات التي تواجهينها؟	نعم، السبب الأكبر هو ضعف التقنية أو عدم تحكم المسؤولين بالتقنية بالشكل الصحيح.
السؤال الخامس: هل دخول الطالبات إلى المعمل/القاعة في غير الأوقات المحددة يؤثر على مهامك؟ كيف ممكن يؤثر؟	نعم، بدخولهم للغرف الغير محجوزة يسبب سوء استخدام الغرف واستغلالها مما يؤدي لجعلنا نعتقد بأنه يقام فيها محاضرة والحقيقة لا.

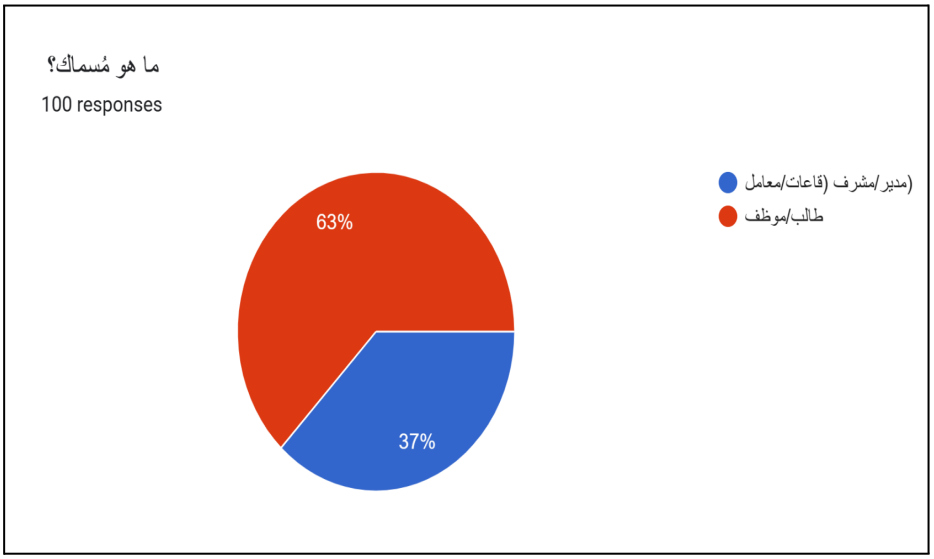
السؤال السادس: هل جودة الهواء في المكان تؤثر على مهامك؟كيف يكون التأثير؟	بالتأكيد، عندما تكون جودة الهواء سيئة خاصة في الغرف التي يحدث فيها تكدس طالبات تكثر الشكاوى.
السؤال السابع: هل درجة الحرارة في المكان تؤثر على مهامك؟كيف يكون التأثير؟	درجة الحرارة تأثيرها أكثر والشكاوى عليها أكثر خاصة في فصل الشتاء والقاعات باردة مما يعيق تركيز الطالبات.
السؤال الثامن: هل معرفتك بإن القاعة/المعمل مشغول في الوقت المجدول يساعدك في بعض مهامك؟كيف ممكن يساعدك ذلك؟	نعم، حتى أخذ الغرف المتاحة بعين الاعتبار في حال احتياج حجز غرفة لمحاضرة أو أيا كان.
السؤال التاسع: هل استخدمتي نظام لإدارة المباني من قبل؟ اذا كانت الاجابة بنعم ، فما الذي أعجبك في هذا النظام تحديدًا؟ و ماهي هي العيوب التي وجدتها في هذا النظام؟	لا.
السؤال العاشر: في حال إنشاء نظام يساعدك في عملية إدارة المبنى ماهي المميزات والخدمات التي ترغبين توفرها بالنظام؟	أجهزة تحكم تلقائية تساعد من نواحي عدة مثل: جودة الهواء، درجة الحرارة، الغرف المحجوزة وتوقيتها.
السؤال الحادي عشر: برأيك ما هي المعلومات التي يجب توفرها في نظام إدارة المباني لمساعدة مديري مبنى؟	عدد الغرف وأوقات المحاضرات/الاجتماعات مع آخر تحديث.

السؤال الثاني عشر: برأيك كيف يمكن تحسين جودة البيئة الداخلية للمبنى باستخدام التقنيات الحديثة؟	بالفلاتر.

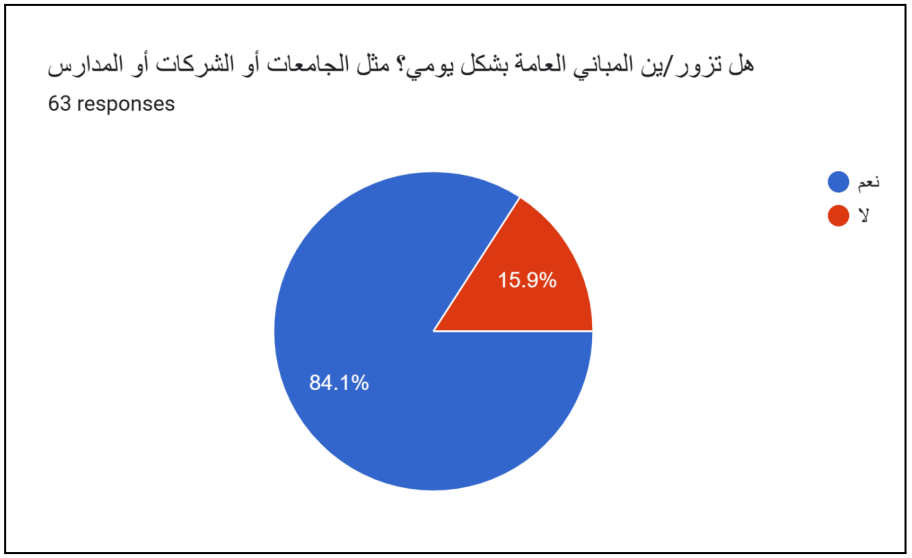
9.2 APPENDIX B: Questionner

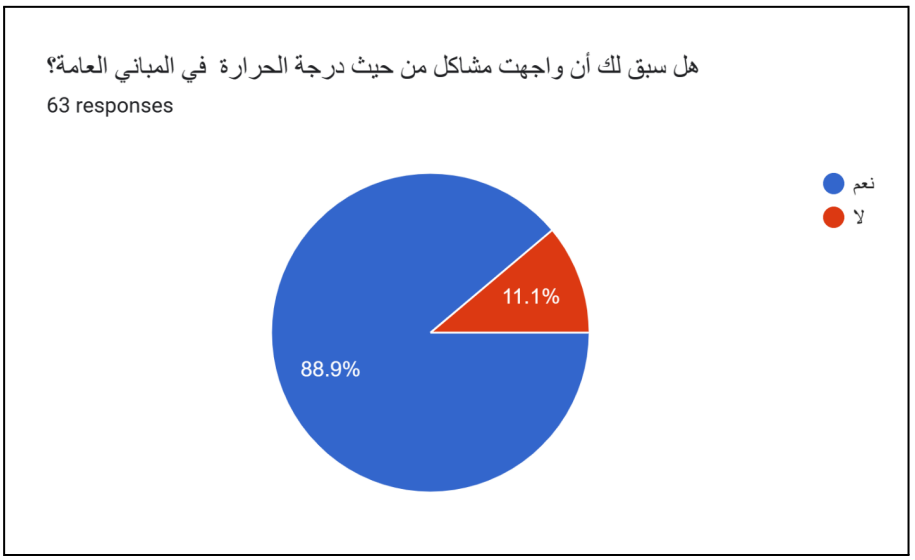
9.2.1 General Question

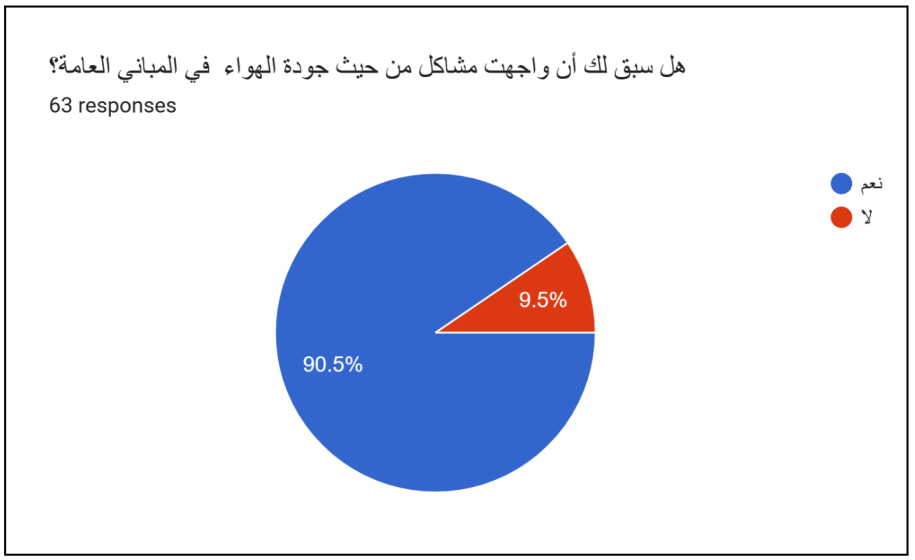




9.2.2 Students & employee Question

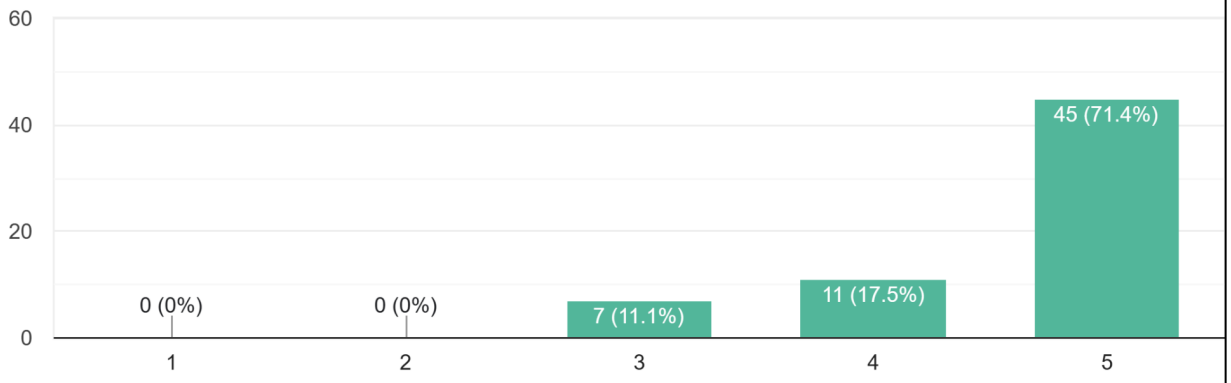






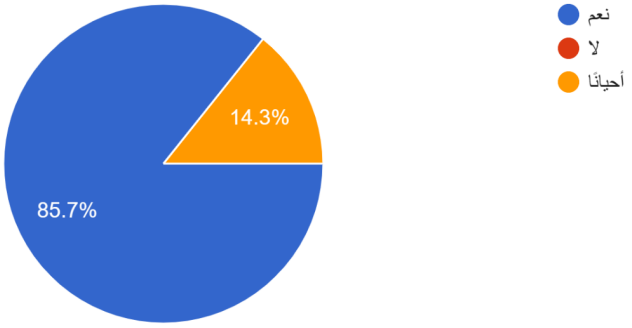
ما مدى إهتمامك بالبيئة الداخلية للمبنى مثل: درجة الحرارة و جودة الهواء؟ حيث أن 1 يدل على أنك (غير مهتم) أما 5 يدل على أنك (مهتم جدا)*

63 responses



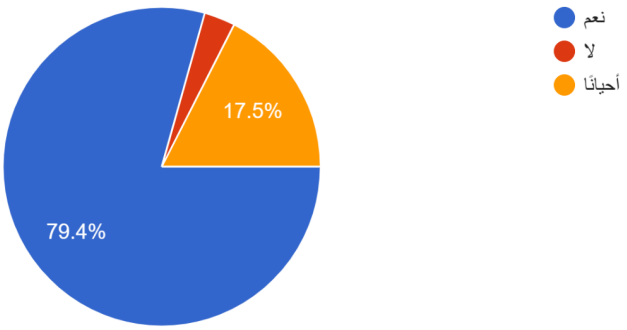
هل تبقى منزعجا عندما تكون درجة حرارة الغرفة داخل المبنى غير ملاءمة ؟

63 responses



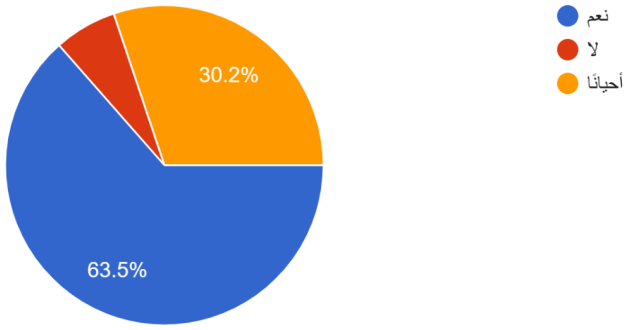
هل تتأثر/ين بجودة الهواء داخل المبنى؟ مثل: الغبار

63 responses



هل تواجه صعوبة في تحسين البيئة الداخلية للغرفة داخل المبنى ؟ مثل: التكييف

63 responses



لأن رأيك يهمنا ، شارك/ي اقتراحاتك و آراؤك حول نظام إلمـام والذي يهدف إلى إدارة المباني مثل:الجامعات والشركات ، من خلال تحسين البيئة الداخلية للمبنى دون انتهاك خصوصية الزائر .

إلمـام - فِـي كُلِّ مكَـانٍ و زمـانْ، رَاحتُك هَدفُنا.

21 responses

/ عمل تكييفات بدرجة حرارة مناسبة / تنقية للهواء

البيئة الداخليه من اهم العوامل المؤثرة على جودة المخرجات سواء للطالب او الموظف الذي يزور المباني العامه بشكل دائم

التحسين من جودة المباني العامه مثل الجامعات و المستشفيات امر مهم جداا و ذالك لوجود زوارها داخلها ل اوقات طويله

يفضل ان يكون تغيير حالة الغرفه يعتمد على اشخاص معينين مثلا دكتوره - موظفه مب كل المتواجدين في الغرفه او المبنى

بالتوفيق

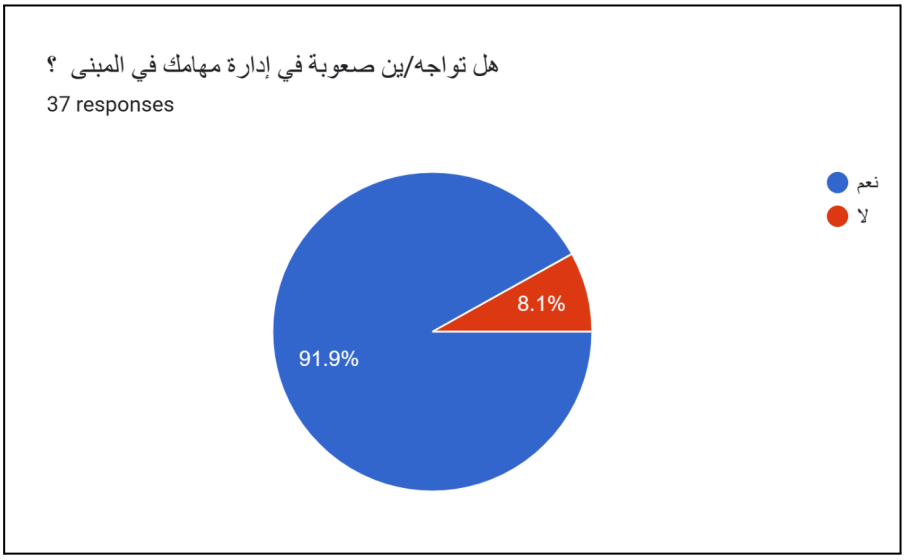
شكرا جزيلا لكم

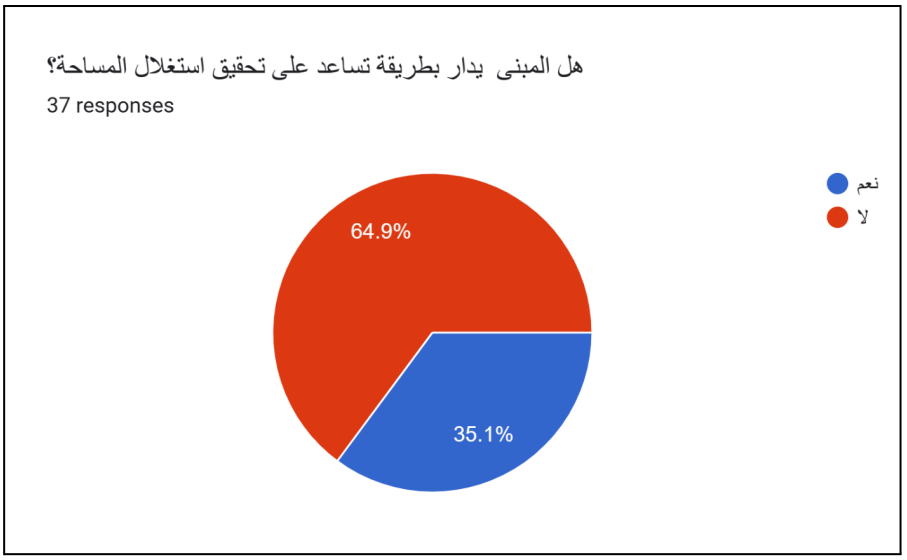
جميلة الفكرة خصوصًا بالجامعات دايمًا التكييف مايناسب أبدًا

المكيف المركزي فكرة سيئة ، يجب ان يجعلوا الطالب أو زائر المكان شريك في عملية تحسين البيئة الداخلية وأخذ التحكم، سالفة إني اموت جمدة والحل الوحيد إني ألبس جاكيت او عباية ثقيلة غير جيدة

اشوف انه فكرة حملة حدًا خصوصا الدام اللي يعانون من الحساسة الحولية و الموسمية

9.2.3 Building managers question





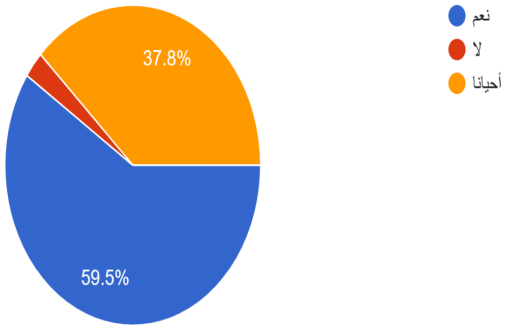
في حال كانت إجابتك (لا) في السؤال السابق برأيك ما الطريقة المناسبة التي قد تساعد في تحقيق استغلال المساحة؟

22 responses

- توفير جدول تنظيمي بالاوقات المتاحة والغير متاحة وإشعاري بإشعارات عندما يكون الفصل فارغ ، حتى يسهل التحكم في الفصول الفارغة وتنفيذ فيها الاجتماعات او الدورات للطالبات
- استخدام تقنيات الحديثة التي توفر لنا معرفة المساحات الغير مستغلة في المبنى ، حتى نستطيع الاستفادة منها
- اضافة ميزة تخبرني عن مدى اشغال المساحات في اسبوع مثلا، استطيع من خلالها كسب احصائيات عن المساحات المستغلة والغير مستغلة
- استخدام الكاميرات التي من الممكن ان تعلمنا عن خُلُوّ القاعة في الوقت المحدد ونستطيع الاسفادة منه
- استخدام تقنيات توضح لنا مدى استخدام الفصل و ومامدى استغلال المساحة في كل فصل
- لا تحضرني حاليًا طريقة معينة ، ولكن اتمنى استغلال جميع المساحات بشكل متناز ليش فقط في الفصول والقاعات بل ايضا حتى في المسارح
- استخدام الذكاء الاصطناعي
- توفير تقارير يومية توضح مدى استخدام المساحات في المبنى ، حيث نستطيع تجنب المشاكل واستغلال المساحات بشكل اكثر في المرات القادمة
- اضافة مرافق في المساحات المهمشه

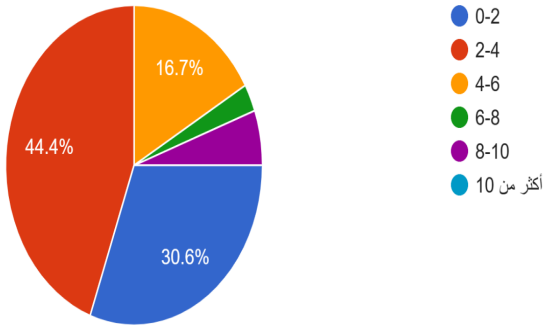
هل واجهتك مشكلة في حجز المعامل/القاعات السلبي؟ *الحجز السلبي: هو حجز القاعة أو الفصل /المعمل في وقت معين من قبل موظفين في المبنى و عدم حضور الشخص في الوقت المحدد

37 responses



في حال كانت إجابتك (بنعم أو أحيانا) في السؤال السابق ماهو معدل حجز المعامل/القاعات السلبي خلال أسبوع في الفصل الماضي؟

36 responses



في حال استخدام المعامل/القاعات السلبي ما مدى الضرر من وجهة نظرك؟

29 responses

يؤثر على الجدول الحضور ومواعيد اقامة الفعاليات في الكليات

استحواذ على مساحات كبيره يمكن استغلالها باشياء اخرى

عدم وجود قاعات مع العلم من توفر قاعات كبيره

تضرر الجدول الزمني للفعاليات التي قد تقام بالجامعة

عادة عند حجز قاعه او مسرح يتم الاتفاق مع عدة أشخاص للفاعالية المقامة لكن عند عدم اقامة الفاعلية يترتب على ذلك خطأ كبير مما يسبب ترك مساحة خالية في وقت قد تحتاج له

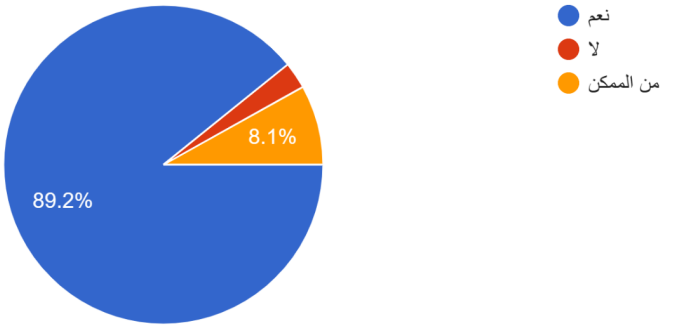
قد يحدث ضرر كبير من دوره التأثير على الجدول المقترح لإقامة الدورات و الفعاليات

اوجها احيانا عند التواصل مع مشرفين لعمل دورات خاصة بالطالبات يتم التنظيم معهم ولكن مافي اي حضور ، مما قد يسبب تراكم في جدول الحصص للطالبات وتأخير في المنهج الدراسي

تأخير في إقامة الاشياء المحددة الاخرى

هل تعتقد أن استخدام المعامل/القاعات في المبنى بواسطة أشخاص غير مصرح لهم قد يؤدي إلى حدوث مشاكل؟

37 responses



في حال كانت إجابتك (بنعم أو من الممكن) في السؤال السابق ماهي المشاكل التي قد تحدث من وجهة نظرك؟

29 responses

قد تتضرر المعدات الخاصة في المبنى، وبالتالي قد تحتاج إلى صيانة والتي بدورها ترفع التكلفة

دخول اشخاص غير مصرح لهم قد يؤثر على جودة المبنى وعلى ممتلكات المبنى

الاستخدام الخاطئ للقاعات

الأثر كبير خاصة في المعامل ، لان الادوات تعتبر من ممتلكات الجامعة ويجب استخدامها بإذن مسبق ، عند استخدامها دون إذن قد يؤثر على خطة سير المنهج التعليمي عندما تكون الأدوات غير متوفره او تم استخدامها من قبل اشخاص آخرين

قد يؤثر ذلك على الادوات الخاصة في المبنى

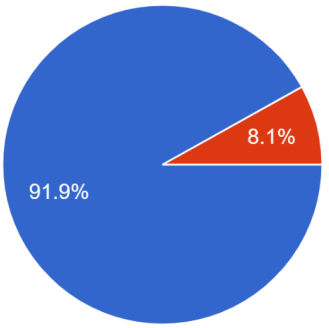
قد يؤثر على الممتلكات الخاصة في المبنى، قد تتم عمليات اخذ للادوات وعدم ارجاعها مما قد يزيد التكلفة

إضرار في الأجهزة ، سرقة الأدوات الخاصة في المبنى، أعطال فنية والحديد...

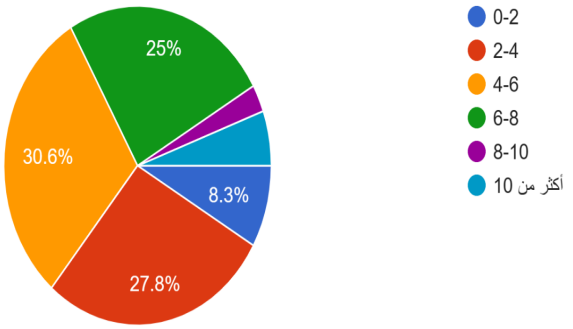
عادة الطالبات يستخدمون المعامل دون اذن من مشرفة المعمل ، وقد تفقد بعض الادوات الخاصة بالمعمل التي من الصعب توفرها مجددًا

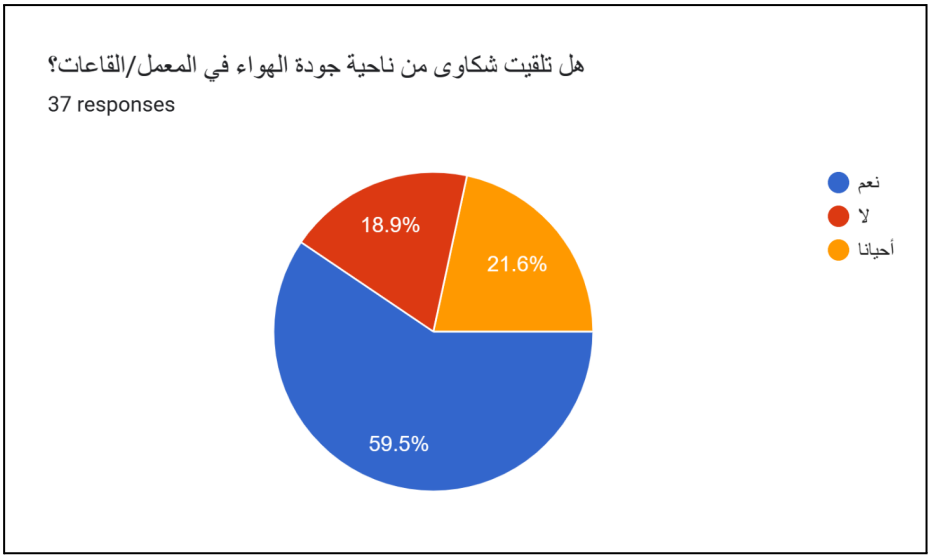
تواجهني عالبا كوني مشرفة للمعامل في المدرسة ف الطالبات لا يملكون اذن بالدخول ويضطر لإغلاق المعمل ، مما قد يسبب مشاكل في ان المعلمة

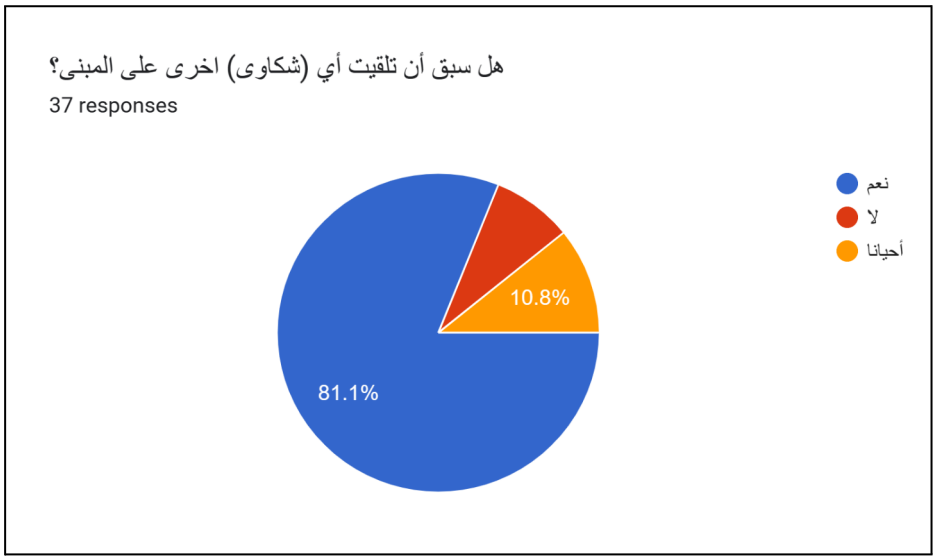
هل تلقيت شكاوى من ناحية درجة حرارة في المعمل/القاعات؟ برودة شديدة - حرارة شديدة
37 responses



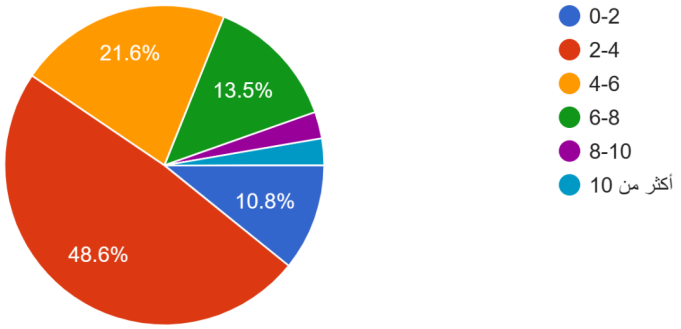
في حال كانت إجابتك (بنعم) كم معدل عدد الشكاوى التي تلقيتها حول درجة الحرارة خلال اسبوع في الفصل الماضي؟
36 responses



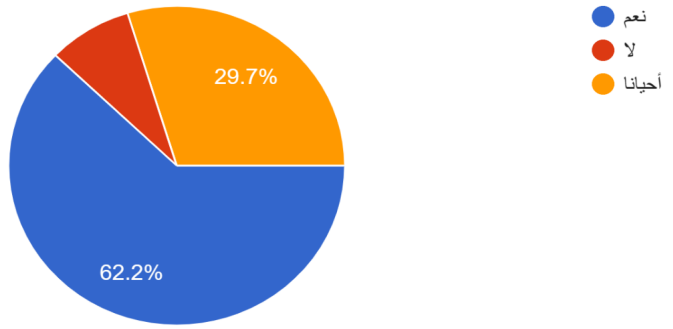

هل تلقيت شكاوى من ناحية جودة الهواء في المعمل/القاعات؟
37 responses
18.9%
21.6%
59.5%
نعم
لا
أحيانا


هل سبق أن تلقيت أي (شكاوى) اخرى على المبنى؟
37 responses
10.8%
81.1%
نعم
لا
أحيانا

كم معدل عدد الشكاوى على البيئة الداخلية للمبنى التي تلقيتها خلال أسبوع في الفصل الماضي؟
37 responses



هل واجهتك صعوبة في تلقي التقرير الأسبوعي لملخص إحصائيات جودة المبنى ؟
37 responses



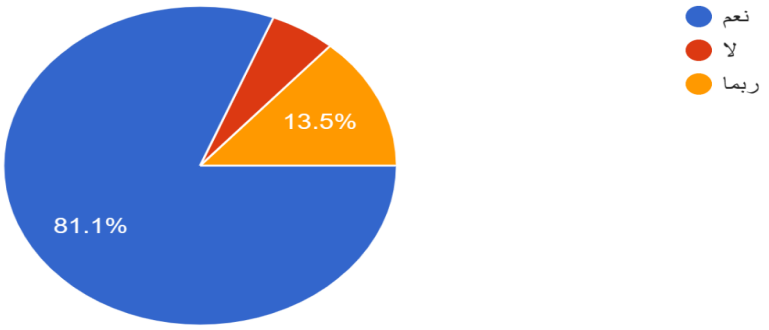
برأيك ما الذي قد يساعدك في تلقي التقرير الأسبوعي للمبنى بشكل أسرع وأسهل؟

37 responses

- تحويل التقارير الى تقارير الكترونية، لان التقارير الورقية متعبة وقد تسبب ضياع احد البيانات المهمة
- وجود مقاييس تسهل علي
- وجود مراقبه بشكل دائم للمباني والقياسات
- زياده عدد الموظفين
- وضع وقت محدد للتقرير
- استخدام التقنيات الحديثة
- توفير موظفين خاصين في ارسال التقارير الى الجهة المسؤولة وموظفين لتحليل النتائج والإحصائيات من التقارير
- ممكن عمليات الصيانة الدورية تقدم خدمة التقرير بعد كل صيانة وترفعها للجهات المختصة
- توفير أداء تعمل على انشاء التقارير والإحصائيات وربطها بالنظام وارسالها للجهات العليا

إذا كان هناك نظام لحل المشاكل السابقة هل تعتقد أنه سيساعدك في إدارة هذه المشاكل؟

37 responses



لأن رأيك يهمنا ، شارك/ي اقتراحاتك و آراؤك حول نظام إلمـام والذي يهدف إلى إدارة المباني مثل:الجامعات والشركات و المدارس، من خلال تحسين البيئة الداخلية للمبنى دون انتهاك خصوصية الزائر .

إلمـام - فِـي كُلِّ مكَـانٍ و زمـانْ، رَاحـتُك هَدفُنا.

37 responses

فكرة النظام فكرة ممتازة واعتقد انها ستفيدنا في المستقبل، اقترح اضافة جهاز يتحكم بالدرجة الحرارة الداخلية للفصل حسب درجة حرارة الجو ، بالتوفيق

شكرا

شُكرًا لكم فكرة جميلة واتمنى تطبيقها

وجود خطط مستقبليه للاداره الفعاله

وجود مراقبه فعاله

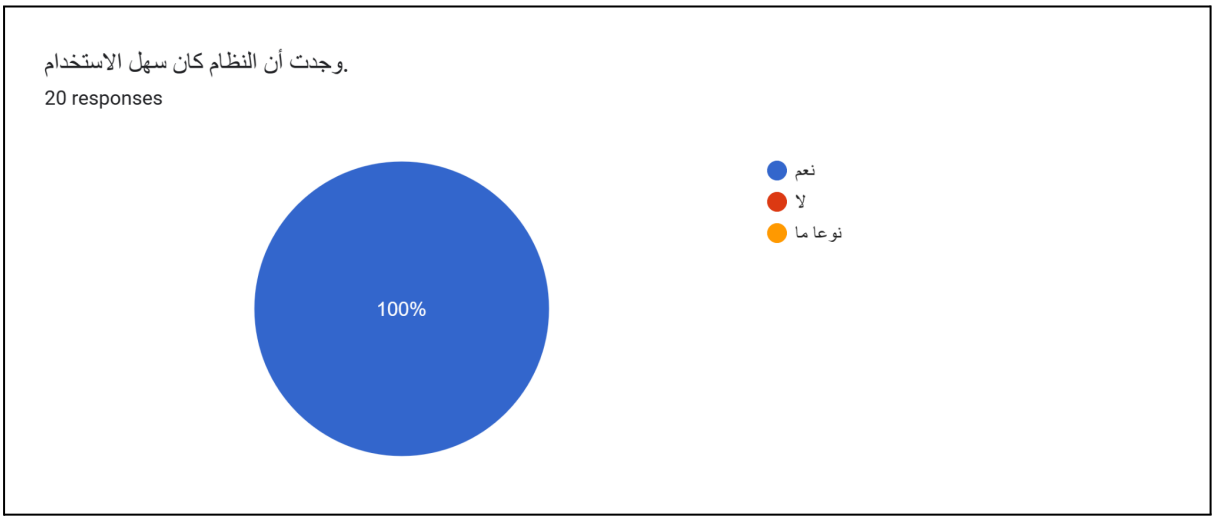
جميل جدا

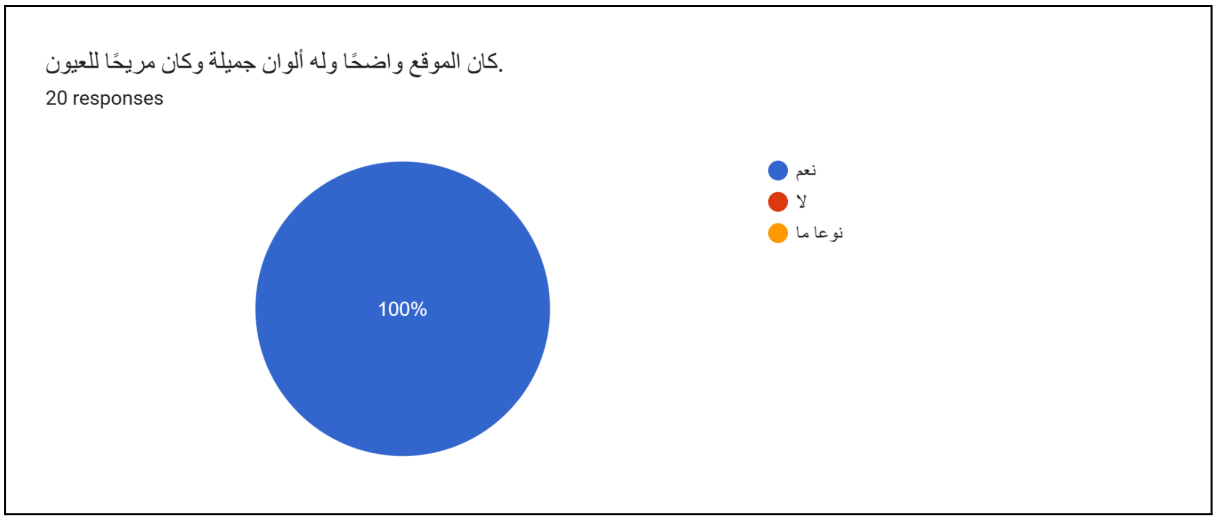
رائع واتمنى استمراره

اتمنى لكم التوفيق ، اقترح اضافة مساعد شخصي باستخدام الذكاء الاصطناعي ، يقدم خدمة معرفة الأدوات المتوفره داخل المعمل

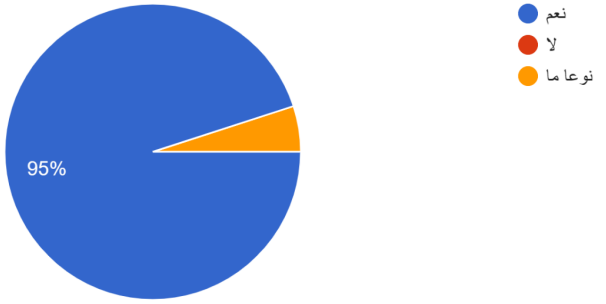
فكرة ممتازة ، واعتقد انها ستحل مشاكل كثيرة بالتوفيق

9.2.4 Testing question

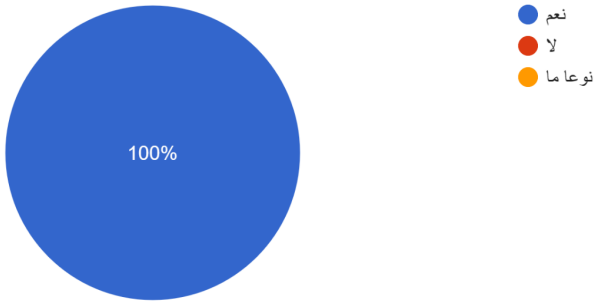




عملت جميع المهام في الموقع بشكل جيد.
20 responses

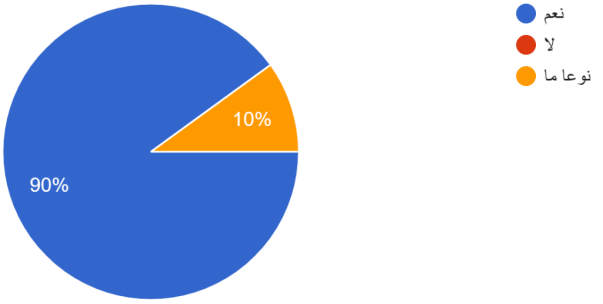


لقد وجدت أنه من السهل التنقل عبر الصفحات.
20 responses



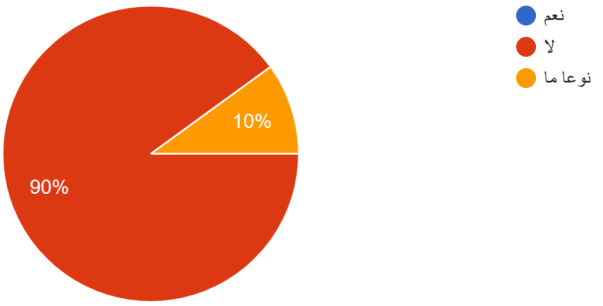
كانت رسائل الخطأ واضحة بالنسبة لي.

20 responses

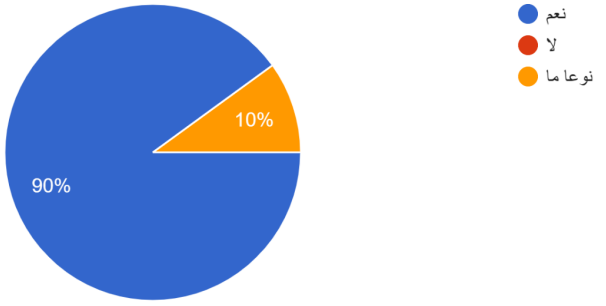


لقد وجدت أن النظام يحتاج الى مساعدة من خبير تقني لاستخدام الموقع.

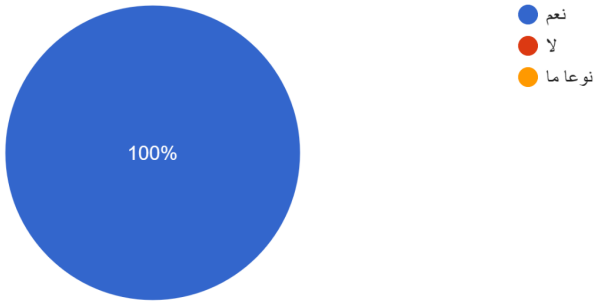
20 responses



لقد وجدت أن النظام يلبي احتياجاتي.
20 responses



كان الأداء العام للموقع مرضيا.
20 responses



ماهي الخدمات التي لم تكن واضحة الاستخدام في الموقع؟

20 responses

لا يوجد

لايوجد

جميع الخدمات واضحة

جميع الخدمات كانت واضحة بشكل ممتاز بالنسبة لي.

في صفحة حالة الغرفة ، اضافة عامودين لل (الجدول الدراسي و الضوضاء) قد يشكل صعوبة بالفهم فاليلا اعتقد من الأفضل ان يكون هناك عامود واحد يدمج بين هاتين الميزتين ويتم عرضها مباشرة لي.

كانت الخدمات جميعها واضحة وسهلة الاستخدام

جميعها كانت واضحة

جميعها واضحه

كل الخدمات كانت واضحه وسهلة الاستخدام

لأن رأيك يهمنا ، شارك/ي اقتراحاتك وملاحظاتك حول النظام

20 responses

اقترح اضافة التحكم من قبلي كمدير المبنى ، حتى استطيع التحكم مباشرة من النظام عند حدوث اي تنبيه

في صفحة عرض الخريطة اقترح أن تكون بحجم أصغر حتى استطيع رؤية جميع الغرف من النظرة الأولى. بالتوفيق

فكرة جميلة ونظام ممتاز بالتوفيق

اقترح ان يكونون الطلاب او زوار المبنى قادرين على استخدام النظام ، حيث في حال تأثر احد الزوار في غرفة معينة يتم رفع طلب من خلال زوار المبنى في الغرفة لحل المشكلة من قبلي مدير المبنى بشكل اسرع.

نظام جميل ، يفضل ان يكون حل المشاكل المتعلقة بدرجة الحرارة و الهواء تلقائيا من النظام دون تدخل مدير المبنى.

نظام رائع جدا

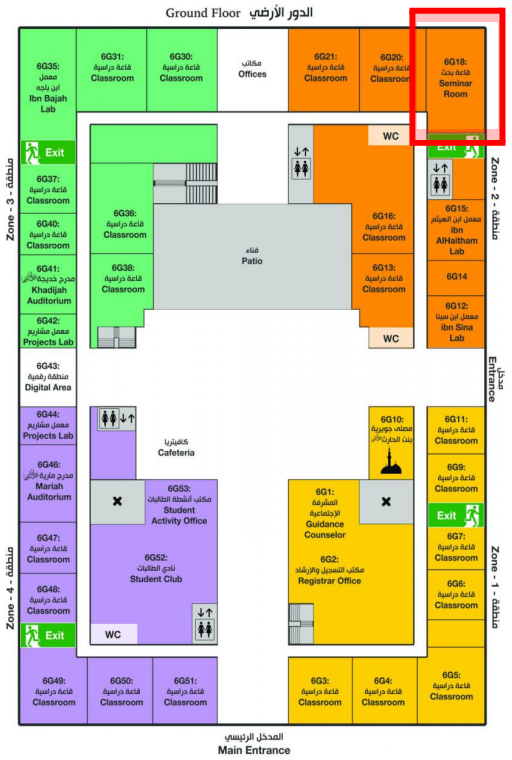
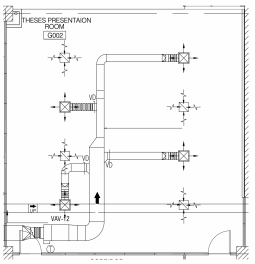
اقترح باضافه مستشعارت للجهاز

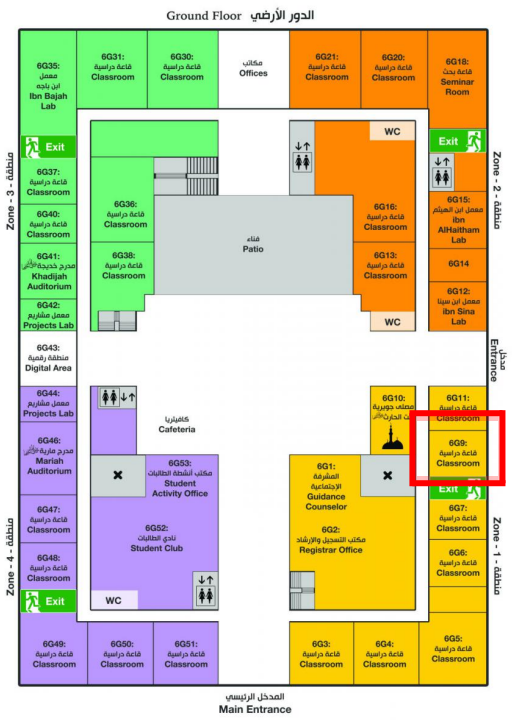
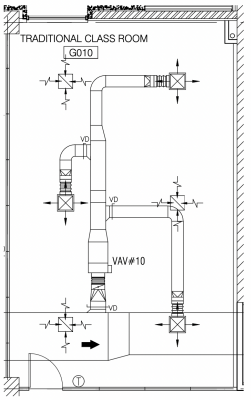
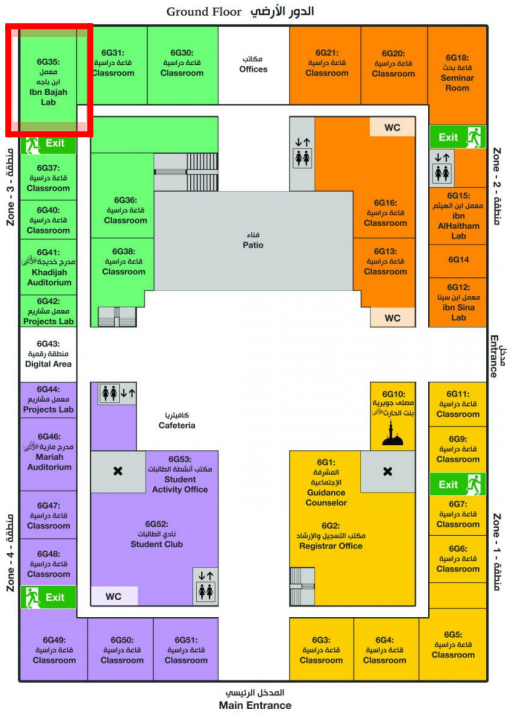
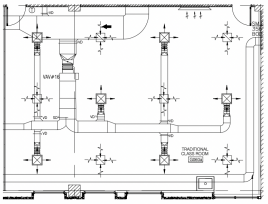
لايوجد جميعها ممتازه

نظام جميل ويخدم احتياجات مديري المباني لكن اعتقد انه يتوسع بحيث يربط اكثر من مبنى

9.3 APPENDIX C: Data collected

9.3.1 Room to monitor

Room number	The room in the floor map	Heating, Ventilation, and Air Conditioning (HVAC) Map
6G18 Seminar room		

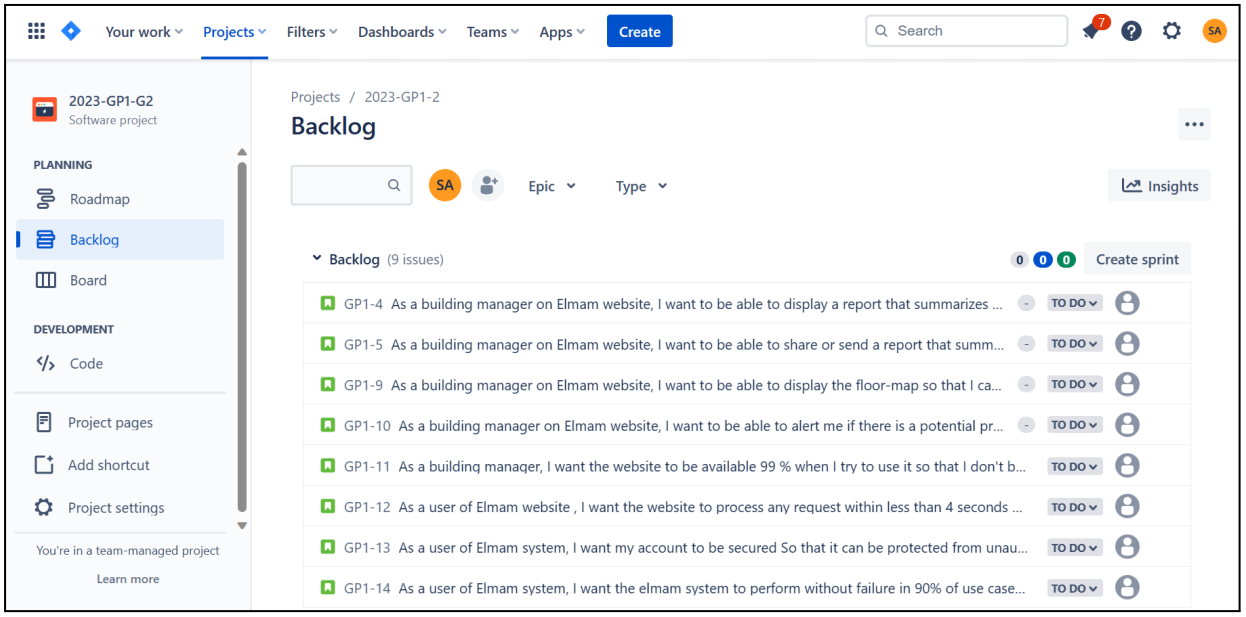
6G09 Classroom		
6G35 Lab		

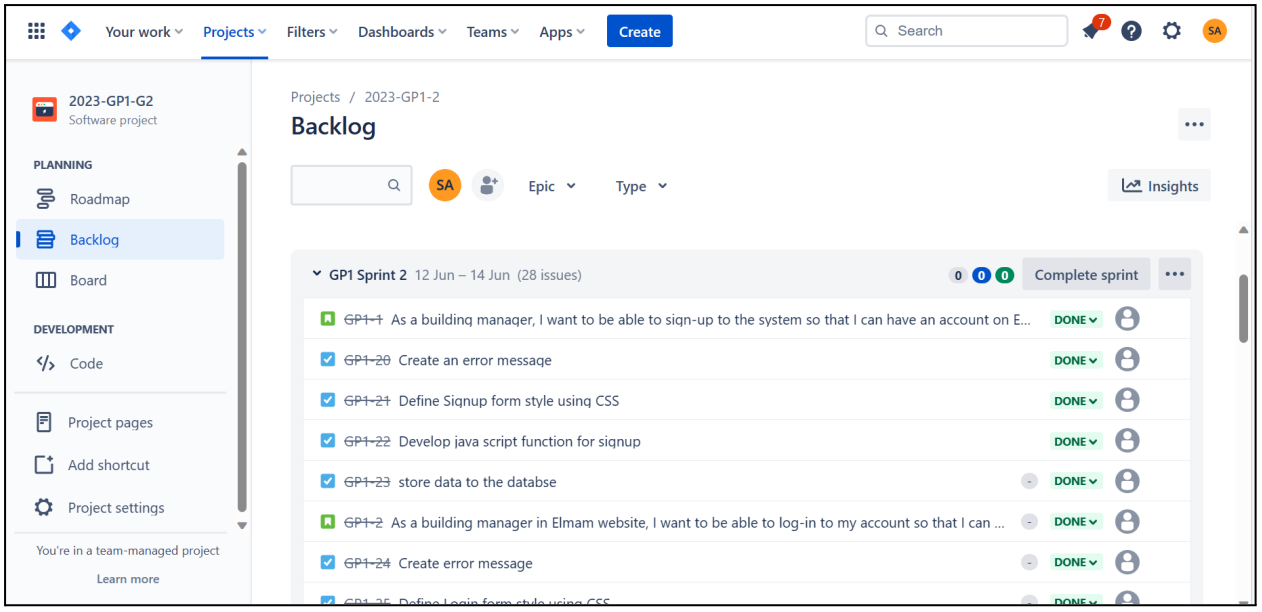
9.3.2 Collected data

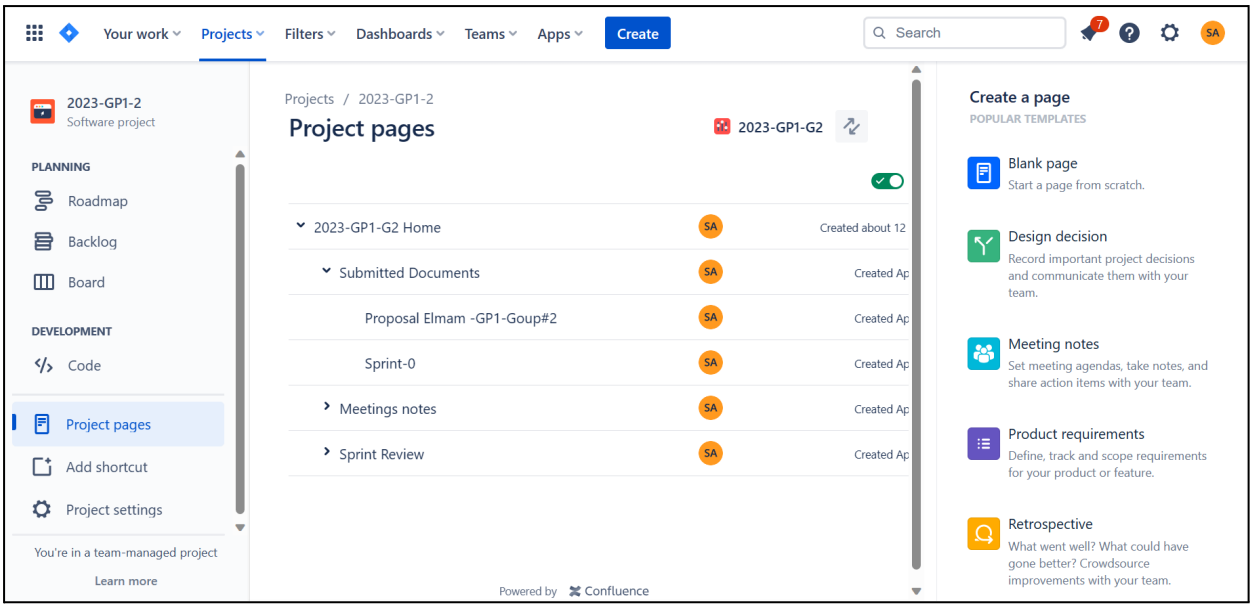
Data collected	Link
Classrooms of the College of Computer and Information Sciences	Link
Schedules (Third semester 22/23)	Link
Schedules (First semester 23/24)	Link
6G09 Classroom	Link
6G18 Seminar room	Link
6G35 Lab	Link

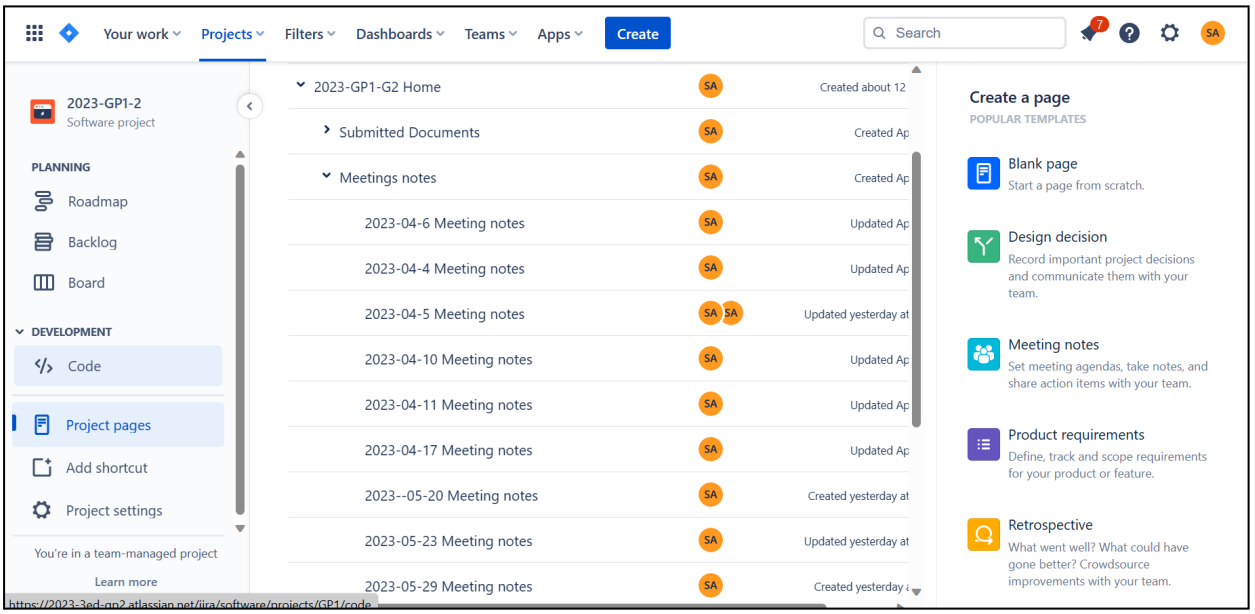
10 Jira

link: GP1 board - Agile board - Jira (atlassian.net)






Your work
Projects
Filters
Dashboards
Teams
Apps
Create
Search
2023-GP1-2
Software project
PLANNING
Roadmap
Backlog
Board
DEVELOPMENT
Code
Project pages
Add shortcut
Project settings
You're in a team-managed project
Learn more
Projects / 2023-GP1-2
Project pages
2023-GP1-G2
2023-GP1-G2 Home
Submitted Documents
Proposal Elmam -GP1-Goup#2
Sprint-0
Meetings notes
Sprint Review
Created about 12
Powered by Confluence
Create a page
POPULAR TEMPLATES
Blank page
Start a page from scratch.
Design decision
Record important project decisions and communicate them with your team.
Meeting notes
Set meeting agendas, take notes, and share action items with your team.
Product requirements
Define, track and scope requirements for your product or feature.
Retrospective
What went well? What could have gone better? Crowdsource improvements with your team.


Your work
Projects
Filters
Dashboards
Teams
Apps
Create
Search
2023-GP1-2
Software project
PLANNING
Roadmap
Backlog
Board
DEVELOPMENT
Code
Project pages
Add shortcut
Project settings
You're in a team-managed project
Learn more
2023-GP1-G2 Home
Submitted Documents
Meetings notes
2023-04-6 Meeting notes
2023-04-4 Meeting notes
2023-04-5 Meeting notes
2023-04-10 Meeting notes
2023-04-11 Meeting notes
2023-04-17 Meeting notes
2023--05-20 Meeting notes
2023-05-23 Meeting notes
2023-05-29 Meeting notes
Created about 12
Updated yesterday at
Created yesterday at
Create a page
POPULAR TEMPLATES
Blank page
Start a page from scratch.
Design decision
Record important project decisions and communicate them with your team.
Meeting notes
Set meeting agendas, take notes, and share action items with your team.
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