



Circlight

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Abstract (English): The traditional way of picking up students and communicating with the school's administrative staff is inefficient and has several problems. The student's pick-up process is time-consuming where parents who want to pick-up their children need to line up in a queue to call their children out and then wait for them outside. Additionally, the current method of parent-school communication includes either reaching out to parents through multiple channels or using paper, which is frequently lost. Circlight attempts to manage and facilitate the pick-up process from school as well as improving the process of parent-school communication. For this to be achieved, special IoT bracelets will be designed along with the platform. The end result is the development of a platform that enables parents who arrive at school to press a button that will cause the child's bracelet to be lighted up which means your parents are waiting outside for you. Moreover, to allow students to find their parents effectively, areas outside schools will be organized into several zones, each of which will have different colors. The parent will inform their children which zone they are in by instructing their bracelet to light up with the same color as their zone. The platform enables parents to delegate someone to pick-up their children. The school's teacher, who is in charge of monitoring the departure, can monitor the pick-up process using the platform's dashboards. Furthermore, the platform is intended to allow the school principal and administration staff to effectively communicate with parents. The system evaluation reveals that the adopted IoT technology and Circlight features have a high level of acceptance either functional or non-functional. And as a result of a test conducted during the experiment using several scenarios, it was found that the system was successful in achieving all of the requirements.

Abstract (Arabic):

الطريقة الحالية لاصطحاب الطلاب والتواصل مع الطاقم الإداري للمدرسة غير فعالة ولديها العديد من المشاكل. تستغرق عملية اصطحاب الطالب وقتاً طويلاً حيث يحتاج الآباء الذين يرغبون في اصطحاب أطفالهم إلى الوقوف في طابور لمناداة أطفالهم ثم انتظارهم في الخارج. بالإضافة إلى ذلك، تتضمن الطريقة الحالية للتواصل بين الوالدين والمدرسة إما بالتواصل معهم من خلال قنوات متعددة أو الورق، والذي غالباً ما يتم فقده. تسعى منصة (Circlight) إلى إدارة وتسهيل عملية اصطحاب الطلاب من المدرسة بالإضافة إلى تحسين عملية التواصل بين الوالدين والمدرسة. لتحقيق ذلك، سيتم تصميم أساور خاصة باستخدام تقنية إنترنت الأشياء حيث تستخدم هذه الأساور مع المنصة. النتيجة النهائية هي تطوير منصة تمكن الآباء الذين يصلون إلى المدرسة من الضغط على زر يؤدي إلى إضاءة سوار الطفل مما يعني أن والديك ينتظرانك في الخارج. علاوة على ذلك، للسماح للطلاب بالعثور على أولياء أمورهم بسرعة وفعالية أكبر، سيتم تنظيم المناطق خارج المدارس إلى عدة مناطق، سيكون لكل منها ألوان مختلفة. سيخبر الآباء أطفالهم بالمنطقة التي يتواجدون فيها عن طريق توجيه سوارهم للإضاءة بنفس لون منطقتهم. تتيح المنصة للأباء تفويض شخص ما



لاصطحاب أطفالهم. ويمكن لمعلم المدرسة، المسؤول عن مراقبة مغادرة الطلاب، مراقبة عملية أصحاب الأطفال باستخدام لوحات المراقبة في المنصة. وتهدف المنصة إلى السماح لمدير المدرسة وموظفي الإداره بالتواصل الفعال مع أولياء الأمور. يكشف تقييم النظام أن تقنية إنترنت الأشياء المعتمدة وميزات المنصة تتمتع بمستوى عالي من القبول. و كنتيجة للاختبار الذي تم إجراؤه أثناء التجربة باستخدام عدة سيناريوهات، تبين أن النظام نجح في تحقيق جميع المتطلبات.

Project URLs

Table 1 Project URL QR code

Tools	URL QR code
Jira project	 URL : https://2022-1st-gp15.atlassian.net/jira/software/projects/QQ2022/boards/1/roadmap
GitHub	 URL : https://github.com/RAlbesher/2022-GP1-15.git
Typeform (Questionnaire's result)	



1 Introduction

Schools aim to foster the conditions surrounding teaching and schooling that include providing a safe environment for students. According to Saudi national curriculum framework for children[1], the children, have no abilities to care for their own safety and protect themselves from danger caused by unfamiliar environment. Therefore, their parents and teachers have a responsibility to take care of them. Children pick-up behaviors have a direct impact on the safety of children as this process might usually causes traffic problems in nearby areas [2]. In Saudi Arabia, the standard procedure for picking-up students was to call children out using schools' microphone. The parents who use this method need to line up in queue to call their children out and then wait for them outside. The children, including early aged, need to keep their attention toward the names have been called. Therefore, some students were sometime going outside to check their parent availability which might cause risk.

There are a variety of ways the school's principal and administration staff communicate with parents. These include social media accounts and paper-based messages that sent with students. In many cases, the paper is lost and thus parent is not aware of the sent messages. Moreover, these communication ways were not suited the emergency such as unpredicted situations or bad weather conditions. In this case, communicating with parents through direct calls might be inefficient or even impossible. In addition, sometimes the parents need to communicate with principal or administration staff. For example, providing the required documents such as sick leaves or update some information or even inform school when they are struggled to reach school on time to pick-up their children.

In view of the important role that technology can play in creating effective school environment that responds to these issues, this project aims to develop a mobile application that improves the pick-up procedure and bridging the gap between parent and school's administration staff (the first application to do so). Circlight intention to use Internet of Things (IoT) technology, particularly a smart bracelet that notifies students when their parent arrived to pick them up and where they can find them in area surrounding the school. The application will also offer communication facilities that allow effective and efficient communication between staff and parents. Moreover, the application aims to consider different scenarios such as when the parents want to delegate another person to pick their children up from school when they are unable to do so such as relatives or school bus driver.



The remaining part of this chapter is structure as follows. 5.1 section describes project problem domain that highlights the main issues considered in Circlight. Then followed by solution in section 5.2 that can be devoted to address introduced problems. In section 5.3 , project vision, suggested road map Project objectives, scope and software and hardware tools are given.

5.1 The Problem

The traditional way of picking students up and communicating with the school's administrative staff has many problems. In this section, problems concerning parents, students, the school's principal and administration are discussed.

In terms of parents, picking children up is time-consuming especially for working parents. Parents must also be aware of the school's schedule, including the line-up time and departure time as well as any parents' meetings or festivals. The traditional method includes giving the children papers to give to their parents, which frequently get lost. Sometime school principal sends messages in public groups on apps such as WhatsApp and Telegram, which may violate the student's privacy. Especially when the announcements should be directed to group of students instead of entire school students.

In terms of students, at departure time students inside the school must pay attention to what has been called in the microphone. This occasionally might not be clear or difficult to follow, especially for primary school students in the crowds or when they are away from the speakers set up in the school. Also, there are some students who prefer to wait outside so they can see their parents quickly, which will cause crowds at the school's entrance. In this respect, children are developing a sense of safety and perception of risk through learning from parents, family, and environment during the early period of their life. This demonstrates that children's positive or negative perception towards self-protection from danger depends mainly on their childhood experience and environment. Improving this experience may contribute to children's safety at a national level.

In terms of the principal and administration, there are several issues including reaching out to the parents. For example, to privately notify them for any concerns regarding their children behave. The schools also need to update their records periodically with information that might be changed at any time throughout the academic year. Moreover, when parents' approval is required to give vaccine at schools. Similarly, paper-based paper was sent with children to home which might be lost or forgotten.



5.2 The Solution

The solution, for the earlier introduced problem, is to develop an application that manages and facilitates the process of picking students up from school in such a way that students' safety is considered. The application intends to enrich students experience through considering student safety and improve their perception toward the rule commitment. For this to be achieved IoT technology will be used, and special bracelets will be designed. Moreover, the application will provide potential for private and public communication with parents.

To pick students up, parents who arrive at school can use the application by pressing a button that will cause the child's bracelet to be lighted up which means your parents are outside waiting for you. The teacher who is responsible for monitoring the departure time allows students who have bracelets turned on to go outside and thus can refuse permitting others. This might help reduce anxiety and fear in children. To allow students finding their parents more quickly and effectively, areas outside schools will be organized in several zones each of which will have different colors. The parent will inform their children which zone they are by instructing bracelet to light up using the zone color. In the case of students using the school bus or other private transportation this feature can be delegated from parents to others through the application. This feature can also be used when the parents ask a friend or relative to pick-up their children. In case parents struggled to reached school on time, schools' teacher who is responsible for monitoring the departure time will be informed.

The application intends to provide potential for the school principal and administration staff to effectively communicate with parents. The communication can be made in public or private. Public communication is made when the announcement related to all parents such as the change in arrival or departure time, or date for parent evening. Private communication is made when the communication concerns one of the parent's children.



5.3 Product

5.3.1 Product Vision

For parents who need to collect their children from school and require direct and private communication with school's administration staffs, the Circlight is a mobile application that allows parents to notify their children of their presence at the departure time. Circlight provides potential bidirectional communication directly with the school principal and parents. Unlike similar systems that offers picking up services our product relays on a simple IoT device that safely monitors students during picking-up and offers a private communication channel.

5.3.2 Objectives

The objectives of this project are described in three main dimensions; product objectives, project objectives and learning objectives introduced respectively in below paragraphs.

Product Objectives:

The student's safety during picking-up time instigates the need to develop this application. In addition to the requirement to offer effective and efficient procedure to pick the children up from school by reducing time and effort required. The application may contribute addressing problems given in problem section (Section 2). The users (Parents and administrative staff) will have flexible and more convenient services that may suit their needs. Product objectives are as follows:

1. Reduce the time and effort required to pick-up the children from school.
2. Make the process more convenient through the IoT devices.
3. Eliminate the potential of leaving students the schools before parents have arrived.
4. Minimize the crowdedness in the school's entrance and the area surrounding.
5. Bridging the gap between administration staff and parents.

Project Objectives:

1. Collect users' needs using a questionnaire and an interview.
2. Write user stories according to the user's requirements.
3. Design and configure the smart bracelet.
4. Implement an android application and connect it with the smart bracelet.
5. Test the system's functional and non-functional requirements.
6. Test the IoT bracelet and make sure that the school student is notified about his parents' presence by lighting up with different colors depending on the zone that his parents are currently in.



Learning Objectives:

Project developers will learn mobile application implementation using Visual Studio Code. Moreover, they will learn how to set, install and deal with smart devices (the bracelet). Developers also aim to develop academic skills concerning academic writing and research.

5.3.3 Scope

Circlight is an Arabic mobile application that can be installed on android smartphones. Circlight will be designed to manage pick-ups of students in all grades in primary schools. Therefore, the target users are primary school administration staff, delegators and parents who want to pick-up their children. The intended users are expected to use mobile applications and able to read in Arabic. Two bracelets will be used to check and test the application.

5.3.4 Hardware/Software Tools and Cost

Project uses the following software and hardware tools:

Table 2 Hardware/Software Tools and Cost

Hardware Tools	
Name and Description	Cost
2 pieces ESP32-S3 chip	It costs 45 SR each, and shipping will take 7 days to be delivered.
Jumper Wires	It costs 4 SR, and shipping will take 7 days to be delivered.
Strip RGB LED Programmable 5v	It costs 65 SR and shipping will take 10 days to be delivered.
Li-ion rechargeable battery 3.7-volt 1200Mah	It costs 66 SR, and shipping will take 11 days to be delivered.
RGB LED Strips Connecters	It costs 39 SR, and shipping will take 3 days to be delivered.
Lithium Battery Charger Module	It costs 58 SR and shipping will take 3 days to be delivered.
NodeMCU	It costs 71 SR and shipping will take 2 days to be delivered.

Software Tools	
Name and Description	Cost
Flutter framework	Free
Visual Studio	Free
GitHub	Free
Jira	Free

Other costs relevant to the project:

The bracelet 3D printing prototype with 150 SR cost.



5.4 Scrum Team

5.4.1 Skills Set Requirements

Table 3 Skill Set Requirements

Technical Skill Required	What is the current level of the team (beginner-intermediate-advanced) for each skill? How will the gap be bridged? (If necessary) Learning plan
Mobile application implementation using Android studio	intermediate Online resources
Set, install and deal with smart devices	Intermediate Online resources
Academic writing and searching	Intermediate Practice writing reports Project supervisor will provide session Academic writing sessions will be provided by the project supervisor.

5.4.2 Learning

We learned several things regarding IoT, mobile application development, and how to deal with Jira and GitHub. For the IoT we have searched for experts to make sure that the selected pieces are compatible, regarding the mobile application development, we used Visual Studio Code to implement flutter framework,in order to learn more about it we have registered in an online course[3].



5.4.3 Roles and Responsibilities

Table 4 Roles and Responsibilities

Scrum Team		
Product Owner (PO):	Dr. Nawal AlMutairi Dr. Lamia Albraheem	
Developers:	Shahad Abahussain Renad Albesher Lama Almajhad Faten Alharbi	
Scrum Master (SM):	Dr. Hind Alrasheed	
Stakeholders:	Parents who have children at schools. Administration staff, school principal and Delegator.	
Member	Role	Responsibilities
Renad Albesher	Leader	Teamwork
Shahad Abahussain	Member	Teamwork
Lama Almajhad	Member	Teamwork
Faten Alharbi	Member	Teamwork



2 Background

This chapter provides background knowledge with respect to three main domains covered in this project including: (i) the smart bracelet IoT technologies available in the market that may provide a solution in Circlight, (ii) current picking up process and (iii) available communication channels between parents and administration staff.

The remainder of this chapter is organized as follows. Section 2.1 will outline the current process used at Saudi's schools for children's pick-ups, while Section 2.2 will demonstrate the adopted method for communication. These processes are intended to be improved in Circlight through the smart bracelet. Therefore, different types of smart bracelets that are available on the market are introduced in Section 2.3. Then the IoT devices need to configure smart bracelets using Arduino are described in Section 2.4. Section 2.5 illustrates the different technologies used to communicate with smart bracelets, which typically include Wi-Fi and Bluetooth.

2.1 Student Pick-up Process

There are several schools that plan for safe picking up procedures which also minimize the crowded surrounding the school area [4]. In many cases, the good procedure relays on school design that offers multiple gates for different type of students such as kindergarten, early grades and high grades and the availability of car parking. This will typically contribute toward reducing the crowded surrounding the school and school gates that will allow students to easily see their parents. Thus, these sorts of schools do not rely on microphones in call students up at release time.

In many Saudi's schools there is only one gate for school and there is limited parking area outside. At dismissal time students are expected to leave their classes and wait for their parents in school backyard. In this case they are expected to pay attention to names called in microphones and leave school when his or her name have been called. Sounds were not always clear especially in schools with large number of students. To address this issue, some schools offer waiting (quite) room where students sit in to hear the school microphone. In adopted procedure, there is no guarantee that students are leaving schools when their parents have arrived, as students including early aged can leave school to check their parent arrival any time[5].

From the forgoing, finding suitable procedure to pick students up is required. The solution needs to avoid using school microphone and provide potential to organize area outside school without changing the current facilities.



2.2 Communication Process

In Saudi's schools, the communication between schools and parents are expected to perform through different channels. According to interview conducted with administration staff and school principal, the Examples include: (i) phone calls, (ii) hand-in papers that sent with students and (iii) WhatsApp, Telegram or SMS messages.

The reported sorts of communication require was to inform parent about important events such as changing dismissal time, festival schedule and parent night. Moreover, it can be required to take consent to give medical vaccine at school, report health or behaviour issues and discuss student's achievement level.

The current communication channels are not effective specially when papers (and forms) were sent in paper base with students who usually forget or lose the papers. Therefore, finding one channel dedicated for such communication is required.

2.3 Smart Bracelet

Nowadays, wearable technology has been produced as a result of technological advancements, and people may now buy fashionable smart wearables that are worn around the wrist and will greatly enhance our quality of life and make our lives easier.

In the market, there are various types of smart bracelets that were used for different purposes including motion detecting, heart rate detecting, GPS positioning. In the following Table 5 , smart bracelets categories according to their purpose will be introduced.

Table 5 Smart Bracelet types

Smart bracelet types	Description
GPS Positioning bracelet	GPS positioning bracelet is a smart bracelet coupled with GPS tracking systems. This type of bracelet empowers the bracelet owner to track it and find out where it is located. Therefore, GPS positioning bracelets were widely used in tracking elderly people and small children [6].



Heart Rate Detecting bracelet	Smart bracelets have the capability to monitor the heart rate for purpose of improve your health. This type of bracelet is accomplished with device that facilitate detecting heartbeat, presenting it in a data format, and then synchronizing it with the relevant application installed in smartphone or tablet. The application can inform you of basic health issues. Therefore, can be used to guide users to improve their health[7].
Motion Detecting bracelet	This kind of smart bracelet has one of the most fundamental capabilities of the smart bracelet which is the motion detection. Such bracelet can generally used for tracking, recording, and guiding athletes. The owner of the smart bracelet may track exercise duration, calories burned, and other information in real time when they are walking, running, jogging, swimming, or participating in any other sport [8].

2.4 Configure Smart Bracelet Using IoT

The previously mentioned smart bracelet may provide solution to picking-up problem. However, as Circlight team also looking for improving the way students finding their parents, additional characteristics were also required. For example, Circlight team want to organize school outside areas to different zones each will be colored differently. This color will guide students, including early aged, to find their parent. When parents were arrived, they can instruct the bracelet to light up with zone color. To this end, we will also consider how to configure bracelet using small IoT devices. Building bracelet from scratch may empower team member with full features and functionality required, but we will also consider available bracelet when candidate is found. But to do so there are many factors to consider, such as what are the features that the available bracelet offers, and are they sufficient to cover all the project's requirements? In our case, many bracelets are available, but some do not support an open-source API, so we cannot customize them or integrate them with our application. While others have open-source APIs, they do not satisfy our requirements, such as controlling many colors on the bracelet as previously mentioned. As a result, starting from scratch was the best choice in our case. In this section brief introduction to major circuits and hardware essential in the development of lighted bracelets is explained in Table 6.

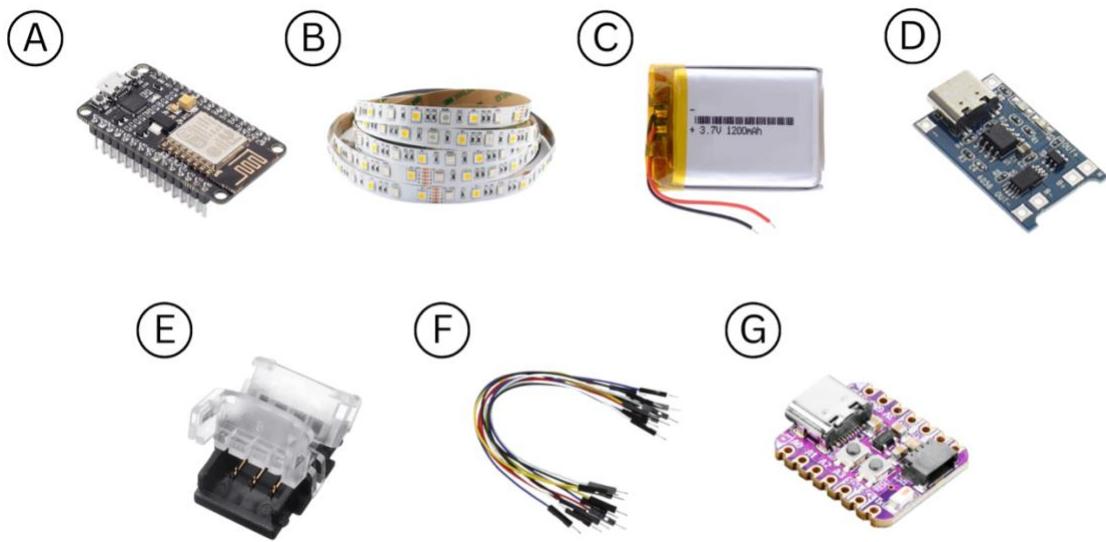


Figure 1 IoT Component



Table 6 IoT Configuration

Images	Component	Description
(A)	NodeMCU (esp8266)	The NodeMCU (micro-controller unit) contains an embedded WiFi chip, the Esp-12E, that facilitates communication with devices. It is possible to convert the data into commands that cause the bracelet to light up and light down. The NodeMCU consumes little energy.
(B)	Strip RGB LED Programmable 5v	RGB (red, green, and blue) LED flexible strip light allows to bend or shape it freely. The length of the cable can be changed by cutting it along the cutting mark or by splicing it. Colors in the visible spectrum can be created by combining red, green, and blue in different proportions. These LED strips are composed of several separate circuits. The color and brightness of every pixel can be individually changed. [7] [10].
(C)	Li-ion rechargeable battery	The battery is the Li-ion rechargeable battery. The most recent battery in terms of recharging technology; it uses 3.7V and 1200mAh. Although it is extremely thin and lightweight compared to other rechargeable chemical batteries, it has a large capacity [11].
(D)	Lithium Battery Charger Module	The lithium battery charger module is designed to charge rechargeable lithium batteries using the constant current/constant-voltage charging method. This module not only ensures that lithium batteries can be safely charged, but it also provides them with the protection that they need [12].
(E)	RGB LED Strips Connecters	These flexible connectors are used to connect wires and LED strips, making connections simpler and more effective. If the LED strips are cut into small circuits, the connector will enable to reassemble the two circuits. [13].
(F)	Jumper Wires	Jumper wires, which are used in circuits that used to link the power supply with NodeMCU chip[14].
(G)	ESP32-S3	ESP32-S3 is a highly integrated Wi-Fi System-on-Chip (SoC) solution chip. It has 2.4 GHz Wi-Fi and Bluetooth Low Energy (BLE) that provides long-range support, as well as built-in native USB. These characteristics make ESP32-S3 easily communicate with other devices by sending and receiving data and instructions. Moreover, Esp32-S3 features low energy consumption [15].



2.5 Wi-Fi And Bluetooth Technologies

The smart bracelet and IoT devices, as explained earlier, adopt different wireless communication technologies, including Bluetooth and Wi-Fi. Therefore, in this section, Bluetooth and Wi-Fi technologies are demonstrated. Moreover, the differences in terms of frequency, speed, power consumption, range, security and bandwidth as well as features offered by each one, and their advantages and drawbacks will be also highlighted.

2.5.1 Wi-Fi

Wi-Fi is a wireless network technology that allows devices such as cellphones, tables, printers, and cameras to communicate and transmit data to one another. Therefore, devices that use this technology are able to establish a network and allow the devices to interact and connect to the internet[16]. Wi-Fi technology has the benefit of replacing cables with radio frequency signals, allowing any wirelessly capable device to use the Wi-Fi signal when it's within Wi-Fi range. The Wi-Fi frequency is basically a range that extends from 2.4GHz to 5GHz and is primarily meant to convey Wi-Fi [17].

In terms of speed, Wi-Fi speed varies based on numerous aspects such as building architecture, obstruction, and Wi-Fi load, but in most circumstances, at least 25 Mbps is required to function properly [18]. When it comes to Wi-Fi power, it varies depending on the device status; if the device is asleep, the Wi-Fi is turned off and does not consume power. There are several benefits to Wi-Fi, including the lack of limitations, the elimination of the need for cables, and simplicity of usage [19]. Moreover, Wi-Fi has several gains, such as convenience, which enables users to access the internet and use it to conduct business from wherever they find it convenient. Also, Wi-Fi provides mobility by enabling users to access the internet from any location and enabling internet-enabled devices to operate anywhere that supports Wi-Fi. And it offers expandability, or the ability of Wi-Fi to operate and power a considerably increasing number of devices transmitting data at once. In addition, many of the machines and devices used to make work easier are powered by Wi-Fi and users can utilize it to complete their tasks in any situation. Therefore, Wi-Fi is considered an important part of productivity [20].

As with any technology, Wi-Fi has two major drawbacks. First is the speed; wireless network speeds range from 1 to 54 Mbps, whereas wired network speeds range from 100 Mbps to several Gbps. The second drawback is reliability, as the case with any wireless network, Wi-Fi is susceptible to data loss due to interference during transmission [20].



2.5.2 Bluetooth

Bluetooth is a wireless technology that enables Bluetooth-enabled devices, such as smartphones and cameras, to interact and exchange data over a short distance. Instead of using cables, it transmits the data using radio frequencies [21]. One of the major gains in Bluetooth is the fact that it does not drain the battery while it is turned on but not in use. In addition, Bluetooth uses 1.6% more power during a four-hour period when it is on but not being used compared to when it is off.

Bluetooth can only operate at a frequency of 2.4GHz [22] [23]. Furthermore, the speed of transfer data using Bluetooth differs based on Bluetooth version; for example, version 4.1 can transport data up to 24MBps, whereas version 1.2 only offers 1Mbps [24]. The Bluetooth technology provides several features, including: (i) low power consumption, (ii) low cost, and (iii) the ability to process data and voice communications at the same time [25]. Bluetooth also offers a number of advantages to Bluetooth-enabled devices, such as being a wireless technology where it does not require wires when attempting to transmit data. Moreover, it does not require any prior knowledge of technology to use because it does not require any software installation or configuration to function and the pairing process is simple. It is also regarded as an efficient technology since it utilizes low-power signals and consumes less battery.

However, there are some drawbacks that make Bluetooth technology unsuitable in some situations. For example, it has slow speed of data transfer, which makes it unsuitable for large file transfers such as audio and video. Although Bluetooth's maximum supported range is 10 meters and the security of Bluetooth is considered to be unreliable [26] [27].

2.5.3 Difference Between Wi-Fi and Bluetooth

Wi-Fi and Bluetooth are considered wireless technologies that exist on most devices, and they both utilize radio signals for data communication. Wi-Fi is preferable to allows internet-enabled device to interact with the internet wirelessly and at high speed whereas Bluetooth is primarily preferable for short-range communication. In this section, the major differences between the two technologies were highlighted summaries the differences.

From the foregoing, it is predictable that Wi-Fi consumes more power compared to Bluetooth. However, Bluetooth offers less security than all the other wireless technologies including the Wi-Fi. Furthermore, Wi-Fi supports expandability, which is the ability to enable users to transmit data and communicate simultaneously, whereas Bluetooth limits the number of devices that can transfer data



and communicate at any point in time. Wi-Fi requires more bandwidth than Bluetooth and thus can cover a wide area that reaches up to 32 meters, whereas the Bluetooth can reach up to 10 meters [27].

Bluetooth seems to be not the appropriate technology to be employed within the Circlight bracelet. As shown in Table 9. The first reason is that the Bluetooth range is very short, up to 10 meters. Given that in schools more than 10 meters will separate the area outside the school from the inside, which is beyond what Bluetooth can handle. Moreover, there may be several obstructions that may prevent the Bluetooth from reaching the students' bracelets. The second reason is that Bluetooth has a limitation on the number of devices that can interact at once. Considering the fact that the bracelet will be used by many students and the bracelets may transfer data at the same time. Therefore, Wi-Fi has a wider range and can support several devices transmitting data at once, it addresses all of these problems and gives us a great method to make the bracelet function effectively.

Table 7 Difference between Wi-Fi and Bluetooth

key	Wi-Fi	Bluetooth
Frequency	- Extends from 2.4GHz to 5GHz	- Bluetooth can only operate at a frequency of 2.4GHz
Speed	- Wi-Fi is faster than Bluetooth	- Bluetooth considered slower than Wi-Fi
Power drain	- Consumes more power than Bluetooth	- Bluetooth consumes less power
Range	- 32 meters	- 10 meters
Security	- It is considered more secure than Bluetooth.	- Bluetooth is less secure than Wi-Fi
Bandwidth	- Wi-Fi require more bandwidth	- Bluetooth has a low bandwidth
Expandability (number of users)	- Wi-Fi enable more users to transmit data and communicate simultaneously	- Bluetooth limits the number of devices that can transfer data and communicate at any point in time



3 Literature Review

In this section, we discuss different research studies that have been conducted to design smart systems to facilitate the process of picking up children from school. In addition, the applications that developed for parent-school communication and organizing pickup process are presented. Moreover, a comparison between different applications is presented to identify the best features that should be considered on the proposed solution.

3.1 Research-Based

In [28], Ying-Wen et al. developed a smart system to organize the process of picking up children at school using NFC technology. The proposed system can identify the parent or delegator using an NFC tag ID. Their IDs were previously stored in the school system. At the time of dismissal, the teacher, using his smartphone, can scan the NFC tags of the person who will pick up the child for verification. This can provide a reliable system to be used for picking up children from school.

In [29], Abdul Subhani et al. developed a smart pick-up system for school children to monitor daily bus transportation. The system can identify the children using RFID tags, and an RFID reader and camera are attached to the bus. The RFID reader reads the RFID tags of the children and sends these IDs to the Raspberry Pi 3 Module to be sent to the GPS Module. All of this information is sent as a text message to the parent's mobile phone, as shown in Figure 2Therefore, parents can know when the children get on or off the bus. In addition, parents can view a live video of the children inside the bus, which can be accessed using a web page. The proposed system is implemented, and the experimental results are presented. The hardware components that were used to implement this system are shown in.



Figure 2 SMS of the Child get down the bus [29]

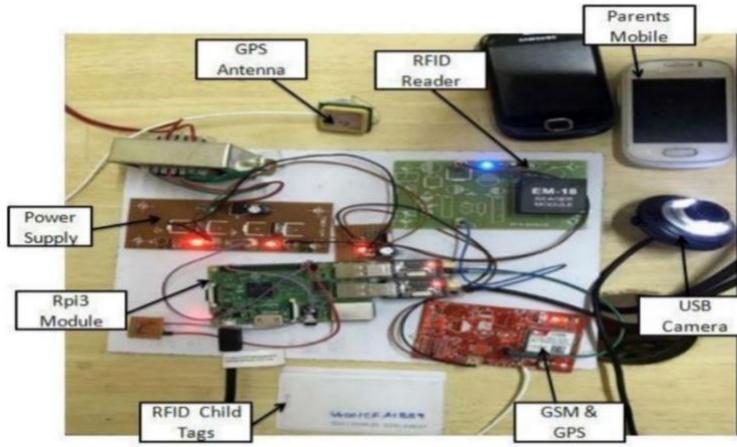


Figure 3 system's hardware [29]

In [30], Shankari et al developed a smart school shuttle application using Bluetooth Low Energy (BLE). The students can be identified using BLE cards, and the shuttle is attached with a BLE reader and localization sensor. The mobile application that was developed in this paper can present the list of passengers in addition to the location information. This application can be accessed by parents. The proposed system was tested, and the results showed it took around one minute to check if the student was active or inactive on the vehicle.

Table 8 Research-Based

Study	Main functions	Technology	Hardware	Software
[28]	Identify the authorized individual person who can pick up their child	NFC	NFC tags, smartphone	Mobile application
[29]	Allow parent and school administrators to know when the children get into or get off bus also to view a live video for the children inside the bus	RFID, GPS	Power Supply Raspberry Pi 3 Module. RFID Reader, RFID Tags SIM808 Module USB Camera	Python Programming Language Raspbian Based Linux Operating system
[30]	Allow parent to track the location of the school shuttle	BLE	BLE reader and localization sensor	Not given

The above-mentioned related works, as shown on Table 8 used different technologies, such as NFC, RFID, and BLE, to manage the process of picking up children from school. Additionally, most of these studies have usually aimed to manage bus transportation. It can also be seen that there is a lack of prior research on this topic. Therefore, it is recommended to explore the new technologies and solutions that can be developed in this field and conduct different experiments to test their reliability. Therefore, this project aims to use IoT technology to control smart bracelets that are used by students to facilitate the



pick-up process. This can be a contribution to the research community and fill the gap in the previous studies.

3.2 Competitive Product Analysis

There are several competitors' products for the Circlight system. These systems can be categorized into: (i) systems that are concerned with organizing the student's departure time; these systems primarily focus on the safe pick-up of students and (ii) systems that are considerate of parent-school communication; these systems place more emphasis on facilitating and increasing the efficiency of school operations. In the following the competitive products are introduced with a brief description of their features.

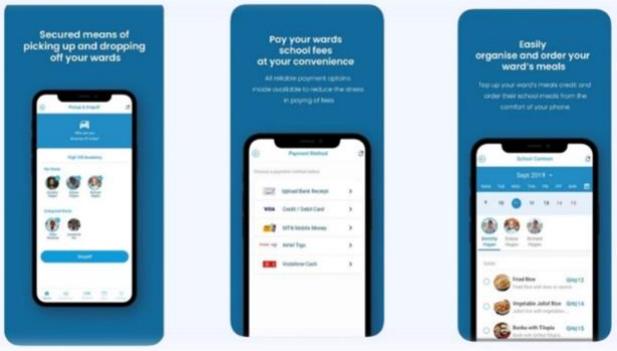


Figure 4 SmartSapp application

Smartsapp is a mobile application developed by Minex360 Company in 2022. It's used in schools to organize the children's departure times [28]. Therefore, one of its key objectives is to organize traffic at the school's entrance and guarantee stress-free and safe child pick-ups. The most important features offered by Smartsapp are:

- Allow parents to pick-up their children using QR-Code
- Enable the delegator to pick-up the children
- Permit the parents to add and delete the delegation whenever they like.
- School fees can be paid digitally
- Allow school to create parent account

The application scans the parent's QR-Code with a scanner available at school entrance before allowing them to pick-up the students to assure their safety. The application will determine whether or not it is authorized to pick-up the child after the scanner verifies the parent's identity.

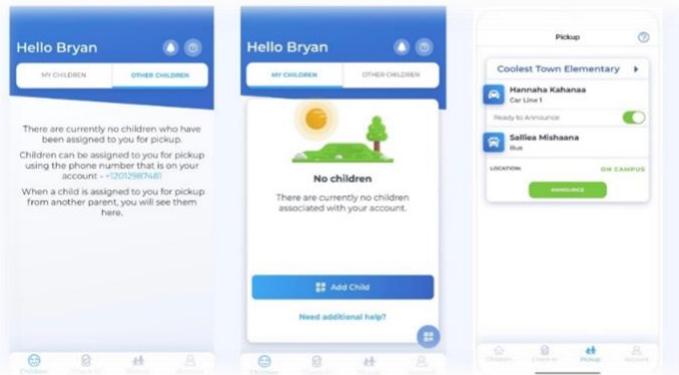


Figure 5 Pikmykid application

Pikmykid is a platform developed in 2015 for all types of schools, including summer camps and after-school activities [29]. It aims to organize the school's operations in a number of areas, such as parent pick-up procedures, dismissal management, and emergencies. The most important features offered by the Pikmykid include:

- Allow parents to pick-up their children
- Provide emergency system notification
- Permit the parents to add and delete the delegation whenever they like.
- Enable the delegator to pick-up the children
- Enable student assignment to their parent by school administration

The application includes key technologies, including GPS, which allows parents to inform their children that they have arrived only when they are in the vicinity of the school, which contributes to managing school operations more effectively. Pikmykid uses advanced algorithms and machine learning to help determine the best route and time to pick-up children and recommend a carpooling option.

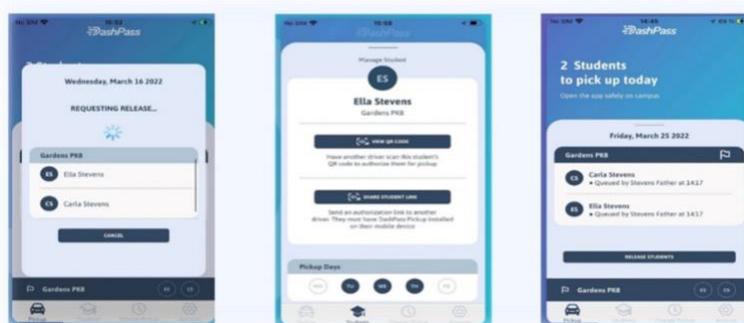


Figure 6 DashPass application



Dashpass is an automated platform launched in 2021. It aims to optimize the student pick-up experience for parents and school staff [30]. The most important features offered by the Dashpass include:

- Allow parents to pick-up their children
- Enable the delegator to pick-up the children
- Allow the delegator registration
- Permit the parent to select the bus route
- Enable student assignment to their parent by school administration

Dashpass automates the dismissal procedure via GPS technology. The student will be queued up for pick-up when the parent's phone is near to the school. The application notifies the school that the parent and child have departed when they leave the school's area.

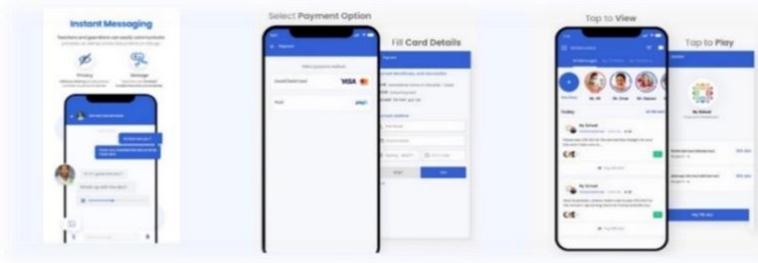


Figure 7 SchoolVoice application

Schoolvoice is a platform that is concerned with communication management and automating communication between schools and parents. It supports a wide range of communication forms between parents and the school [31]. The key features offered by Schoolvoice include:

- Send a public announcement
- Send a private announcement
- School fees can be paid digitally
- Allow school to create parent account
- Enable student assignment to their parent by school administration

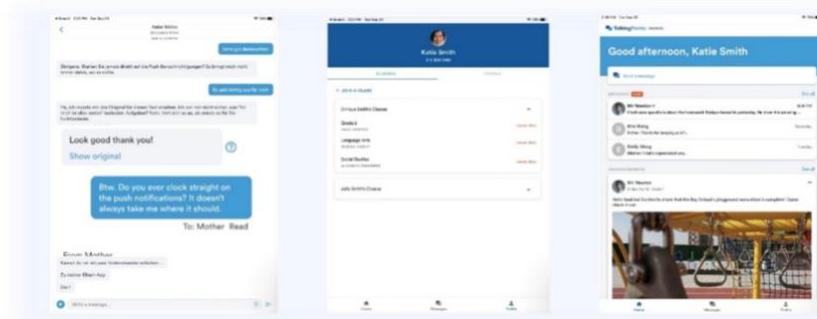


Figure 8 TalkingPoints application

TalkingPoints is a non-profit educational technology that assists schools and districts in managing parent-school communication. It offers two-way enhanced translation to enable communication with parents in their native languages and increase parent engagement with schools [32]. The primary features offered by TalkingPoints include:

- Send a public announcement
- Send a private announcement
- Allow school-parent communication
- Enable creating class by the teacher
- Allow the addition of a student to class

In the following Table 9, competitor products are compared with Circlight potential features. The mark (Yes) means the system provides the feature while the mark (No) means the feature is not provided. In some systems, there is no clear information whether a system offers a feature or not in this case Not Available (NA) mark is used. And it will include technologies employed in certain application.

Table 9 Combative system features compared to potential Circlight features

Features	Competitors					Circlight
	Smartsapp	Pikmykid	DashPass	SchoolVoice	TalkingPoints	
Allow parents to pick-up their children	Yes	Yes	Yes	No	No	Yes
Enable the delegator to pick-up the children	Yes	Yes	Yes	No	No	Yes
Permit the parents to add and delete the delegation whenever they like.	Yes	Yes	NA	No	No	Yes
School fees can be paid digitally	Yes	No	No	Yes	No	No
Allow school to create parent account	Yes	No	Yes	Yes	No	Yes
Enable student assignment to their parent by school administration	Yes	No	Yes	Yes	No	Yes
Allow the delegator registration	No	No	Yes	No	No	Yes
Send a public announcement	No	No	No	Yes	Yes	Yes
Send a private announcement	No	Yes	No	Yes	Yes	Yes
Allow school-parent communication	No	No	No	Yes	Yes	Yes
Permit school to specify the number of zones for the pick-ups	No	No	No	No	No	Yes
Technologies	QR-Code Scanner	GPS	GPS	No	No	IoT Wearable bracelet

3.3 Discussion

Three of the competitor systems concentrated on managing the school's dismissal to ensure stress-free and safe child pick-up and offered desirable features like allowing parents and delegator to pick-up the students. Moreover, these systems employ technology to support these features. One of these systems is Smartsapp provides a QR-Code that can be read by the Smartsapp QR-Code scanner to verify the identity of the parent or the delegator. The other two systems employ the phone's camera to read the QR-Code, and they also make use of GPS technology to determine whether the parent is in the vicinity of the school or not. The remaining two competitors, SchoolVoice and Talkingpoints, do not address school dismissals and thus do not offer the main features: (i) allow parents to pick-up their children, (ii) enable the delegator to pick-up the children, (iii) permit the parents to delete the delegation and (iv) allow the delegator registration. Their primary concern is to provide communication between parents and schools in order to increase parents' engagement with schools.

All the mentioned features in competitive systems, given in Table 9, are intended to be included in the Circlight system which aims to organize dismissal times for children in order to ensure their safety as well as parent-school communication to provide for parents and schools a productive way to interact and communicate. Furthermore, combining the two aspects which are parent-school communication and organizing dismissal times into a single system will enhance and manage the operations of the school in a more efficient way. In addition, because it can be difficult for children to locate their parents in the crowds, Circlight system gives parents the ability to inform their children of the zone in which they can be found. Moreover, by allowing only students whose bracelets are lighted-up to leave school, the Circlight's wearable bracelet aids the teacher who is responsible for monitoring the departure time in controlling the pick-up procedure. Additionally, Circlight system contributes to raising the children's awareness and understanding the importance of safety for children by providing a bracelet for the children to wear and making them understand not to go out of the school if their parents didn't make their bracelet light up. However, Circlight system does not support the digital payment feature, which will not be effective in the current environment, where canteens in schools do not support digital payment.

4 System Design and Development

4.1 Methodology

The Circlight system was developed using Agile methodology. A five-sprint approach was used to successfully complete the project. It took almost a month for each sprint to conclude. At the end of every sprint, continuous development and improvements are implemented with ongoing communication with stakeholders. At the beginning of each sprint, the developers work on a plan to achieve small goals by the end of the sprint, developing and testing a shippable product under supervision by a supervisor and presenting it to the scrum masters at the end. Furthermore, Jira software was used by the developers to track the work between the developers, supervisor, and scrum master, recorded weekly meeting notes with the supervisor, and held sprint review meetings with the scrum masters. The following table shows the roles and responsibilities of the scrum team:

Table 10 Roles and Responsibilities

Scrum Team	
Product Owner (PO):	Dr. Nawal AlMutairi Dr. Lamia Albraheem
Developers:	Shahad Abahussain Renad Albeshier Lama Almajhad Faten Alharbi
Scrum Master (SM):	Dr. Hind Alrasheed
Stakeholders:	Parents who have children at schools. Administration staff, school principal and Delegator specially bus drivers.

In order to collaborate and allow team members to work together, the developers used GitHub as a code source to upload project code, libraries, and other resource files. Additionally, as part of the development team's management tool, Jira software was used to track the work of the developers, supervisor, and scrum master as well as record notes from weekly meetings with the supervisor and sprint reviews with the scrum master.

GitHub Repository: <https://github.com/RAlbesher/2022-GP1-15>

Jira Project: https: <https://2022-1st-gp15.atlassian.net/jira/software/projects/QQ2022/boards/1>

4.2 System Requirements

This section covers four subsections that present system requirements: (i) users, (ii) requirements elicitation and analysis , (iii) architecture , (iv) use case diagram .

4.2.1 System Users

There are four different categories of users in Circlight system as illustrated below:

- **Student:** The school students who are wearing smart bracelet and waiting for the bracelet to light up. Student are expected to have internet connection and distinguish different colors and know each region color.
- **Parent:** The students' parents who are login in Circlight and aiming to receive announcements from school, picking-up their children or delegate someone else to pick-up them. Parents are expected to have smart phone with internet connection.
- **Administrator:** The administration employee with intermediate education and basic computer skills. The administrator is expected to have smart device, internet connection and can understand how to deal with utility applications.
- **Delegator:** The delegator who registered in Circlight and responsible to pick-up the children and has Arabic/English skills. Delegators are expected to have smart device with internet connection.

4.2.2 Requirements Elicitation and Analysis

Interviews and questionnaires were used in order to enhance the current pick-up and communication procedures at the school, and to gather Circlight requirements. We conducted 9 interviews with the different school's administrators and delegators, where a total of 206 responses have been gathered from both parents and students. We have also conducted six interviews with both female and male school administrators. Each interview consisted of the 15 questions provided in Appendix A: Admin interview. For the delegator interview, we have conducted three different interviews with three delegators (bus drivers) and asked each of them six questions.

For the questionnaire, both parents and students were given access to the survey. It contained 21 questions, 16 questions for parents which are provided in **Appendix**, 4 questions for students, and one question to determine whether the respondent was a parent or a student. Before the students began the questionnaire, we acquired parental consent to ask their children and to use this information in studies and research. The findings of the questionnaire are available appendix, and all interviews and questionnaires are included in the **Appendix** Section.

- Interview Findings

Six school administrators have been interviewed. The two major issues highlighted by interviewed administrators were the communication with parents (sending the request and receiving) and traffic congestion when picking-up students from school. Students frequently lose school forms, causing the need for a replacement, especially if these forms are essential. They also affected by parents' delayed to their children, as well as the children's worry because of this delay, and when using calls or means of communication with them, some of them do not respond. Schools are also severely overcrowded in front of the school gate, making it difficult for the child to find his parent.

According to the interviewed administrators, adding coloured zones to regulate the picking-up process may be a feasible solution, and most schools agreed on dividing the area outside the school into two coloured zones. Also, the interviewed administrators stated that they struggle with communication with parents since there is no official method to do it; communication with parents is done through phone calls, papers, or social media platforms such as WhatsApp and Telegram. They also stated that they are having difficulty using paper forms since students may forget or lose them, and they might include important information such as consent to take a vaccine or complete personal data. The interviewed administrators suggest the following feature to be incorporated in Circlight system: (i) The application records the number of times the parents are late, (ii) The application allow parent to view the student status and grades.

- Questionnaires Findings

Questionnaire were used to gather Circlight requirements from parents and students' point of view. Most students and parents agreed on three major issues highlighted by parents and students interviewed: finding parking, finding the parents outside school, and calling a child using the microphone. The parents usually come to pick-up their children at exit time, which causes congestion so that they can't find parking to park their cars and call their children. Also, when parents park to call their children, they may not hear them because of noise, or they may play. This causes congestion in parking lots because the children are late for their parents, so they stop their cars anywhere and stop the traffic in front of the school. With this crowding, it's difficult for children, even if they go out to go to their parents, to find them in this severe crowding and disturbance.

The one about the severity of children waiting for their parents outside school had the highest percentage of agreement: 97.5% of parents agreed that leaving children at school without being called is dangerous and can cause accidents. 65.3% of parents and 51.2% of students are not satisfied with the current pick-up process.

Also, 71.1% of the students had difficulty finding their parents outside of school. 88.9% of students find that using a bracelet to inform them that their parents are outside is easier than using the microphone. Also, we found out that 55.9% of parents take a half hour to pick-up their children, while 36.6% and 7.5% take a half hour to an hour or more to pick-up their children. 88.2% agreed that using a smart (lightning) bracelet to pick-up their children is better than using a microphone, and they agree that their children can use it. Also, 49.7% of parents believe that using colored regions will contribute to regulating traffic and help the child reach his parents.

57.8% of parents call the school when they assume a child will be late, and 36% come late without informing the school or shift teacher. 73% of parents facing a communicating problem with the school as there is an important event in school and they were not informed of it. Also, parents mentioned the most cases that require them to communicate with the school as report a health problem, late arrival and excuse absence.

4.2.3 User Interaction

Use case diagram is given in Figure 8 that shows major user interaction with system. As mentioned in section 4.1, four different types of users (actors) are founded in Circlight ; Student, parent, administrator and delegator .The parent actor has features that include the following: Account managements features that include login and log out to Circlight account , send request to school, pick-up children from school , edit profile , also they can delegate someone else to pick-up their children. In Circlight, administrator actor has account managements features as login and log out, view dashboard, Search for parents, search for students, manage parent, manage students, send a private and public announcement. Delegator actor in Circlight has account managements as register, login and log out, view list of students that have been delegated to a delegator user, he can also pick-up delegated students.

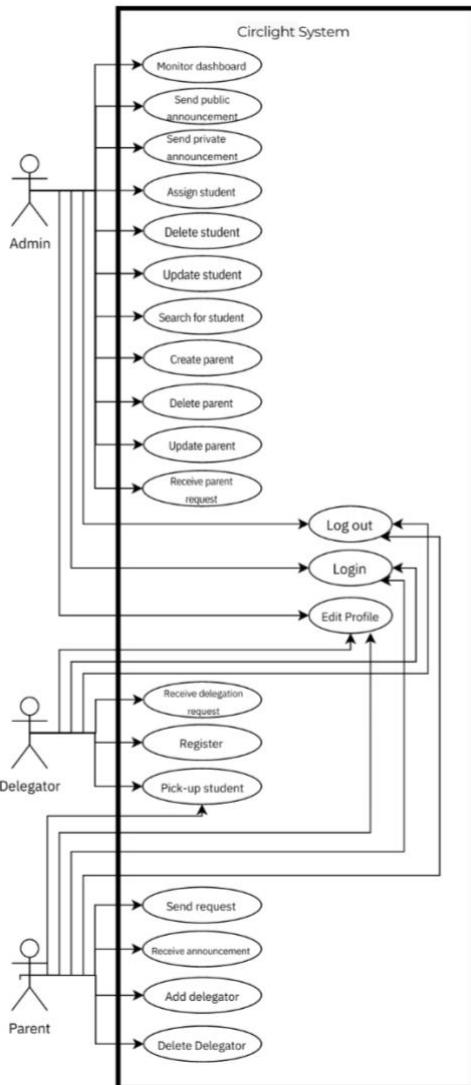


Figure 9 Use Case Diagram

4.2.4 Roadmap and Product Backlog

In this project, two releases are used, with two sprints in the first release and three sprints in the second release. The first release will be conducted in the first semester and the second release will be in the second semester. Release 1 and release 2 are given in Table 11.

Table 11 Product Roadmap

Release 1				
Sprint #: 0	Start date:	11 Sep	End date:	29 Sep
Target Project Objectives:				
<ul style="list-style-type: none"> - Design the bracelets (Determine the components that will be used to configure the bracelet and check their compatibility) - Order required devices. - Install required software. - Prepare the background and domain analysis. - Collect users' needs by questionnaires and interview. - Write the user stories and prepare backlog. - Revise target project objectives after collecting users' needs (new might be added). 				
Learn how to use the following:				
<ul style="list-style-type: none"> - Visual Studio Code to implement flutter framework for mobile applications - GitHub to host project code that can be shared with relevant teams (examiner and scrum master). - Jira to plan, track, and manage project development. - Learn required skills to develop IoT applications. 				
Sprint #: 1	Start date:	9 Oct	End date:	1 Nov
Target Project Objectives:				
<ul style="list-style-type: none"> -Build and deploy the database. -Connect interface to the database 				
Implement some main functions such as:				
<ul style="list-style-type: none"> (i) Create parent accounts by school administration staff. (ii) Assign child (student) to their parent account. (iii) Delete student by the administration. (iv) Delete parent account by the administration. (v) Update parent account by the administration. (vi) Update student by the administration. (vii) Configure the smart bracelet. 				

Release 2

Sprint #: 2	Start date:	TBD	End date:	TBD
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Target Project Objectives:

Complete developing Circlight app with following features:

- (i) Register as delegator user
- (ii) Implement the pick-up function for parent and delegator
- (iii) Add delegator by the parent
- (iv) Receive delegation request from parent
- (v) Delete delegator
- (vi) Search for student

Sprint #: 3	Start date:	TBD	End date:	TBD
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Target Project Objectives:

Complete developing Circlight app with more features:

- (i) Implement a dashboard for monitoring the pick-up process.
- (ii) Send a private announcement to target parents.
- (iii) Send a public announcement to the parents.
- (iv) Receive announcement by parent.

Sprint #: 4	Start date:	TBD	End date:	TBD
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Target Project Objectives:

Complete developing Circlight app with more features:

- (i) Log in
- (ii) Log out
- (iii) Send request by parent.
- (iv) Receive parent request.
- (v) Edit profile
- (vi) Forget account password.

Table 12 Definition Of Ready

Example Definition of Ready	
	User story is achievable within a sprint
	User story has clear dependencies
	Work is prioritized
	Team understands the acceptance criteria
	Team accepted the sprint backlog
	User story should have test criteria defined.
	Details are sufficiently understood

Table 13 Product Backlog

PBI (user story)	Size (Story points)	Type (Feature, defect, technical work, knowledge acquisition)	Status	Acceptance Criteria The conditions of satisfaction that must be met for that item to be accepted.
1- As an Admin I want to be able to create a parent account so that parent can login to Circlight application.	3	Feature	Done	- As an Admin if I click on create parent button then I should be able to enter parent information and create parent account.

				<ul style="list-style-type: none"> - As an Admin if I try to create parent account that already exists then the creation should fail and the message "This parent already exists" should appear.
2- As an Admin I want to be able to share the created parent account (username – password) in non-paper-based method so that parent can gain access to their account.	3	Feature	Done	<ul style="list-style-type: none"> - As an Admin if I click on create parent button, enter the parent information, and click "Create," then I will be able to share the parent created account with the parent.
3- As an Admin I want to be able to assign students to their parent so that I can connect them together.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin if I searched for a parent and click on add student then I should be able to enter student information and click assign to assign the student to this parent. - As an Admin, if I click on assign student with incomplete or

				missing information, then the message "You should fill in all information" should appear.
4- As an Admin I want to be able to delete students so that I can remove students who are no longer registered in school.	3	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I click on delete and confirmed the deletion, then the student should no longer be available and will be deleted. - As an Admin, if I click on the delete button and did not confirm the deletion then the student should not be deleted.
5- As an Admin I want to be able to delete the parent so that I can remove parents that their children are no longer registered in school.	3	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I click on delete parent and confirmed the deletion, then the parent should no longer be available and will be deleted.

				<ul style="list-style-type: none"> - As an Admin, if I click on the delete button and did not confirm the deletion then the student should not be deleted.
6- As an Admin I want to be able to update the parent's information so that I can keep the parent data up to date.	3	Feature	Done	<ul style="list-style-type: none"> - As an Admin if I update parent's information, then appropriate message should appear to indicate that the information is updated.
7- As an Admin I want to be able to update student information so that I can keep the student data up to date.	3	Feature	Done	<ul style="list-style-type: none"> - As an Admin if I update student's information, then appropriate message should appear to indicate that the information is updated. - As an Admin if search for the particular student and click on update then I should be able to update student information.

8- As an Admin I want to be able to reassign the student so that I can correct my mistake if I assign the student to an incorrect parent.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin if I want to update the parent profile and click on reassign choose the correct parent then an appropriate message should appear to indicate that the student is reassigned. - As an Admin if I reassign the student to a new parent, then the student should be deleted and no longer assigned to that previous parent.
9- As a Delegator I want to be able to register so that I can use Circlight application.	2	Feature	Done	<ul style="list-style-type: none"> - As a Delegator, if I go to the sign-up page and enter the required information and clicked on register then I should be successfully registered and able to login with this information.

				<ul style="list-style-type: none"> - As a Delegator, if I go to the sign-up page and enter incomplete or missing information and click register, then the registration will fail with an appropriate message.
10- As a Parent I want to pick-up my child by notifying him about my presence, so that my child can leave the school when his bracelet lighted up.	5	Feature	Done	<ul style="list-style-type: none"> - arrive page, and click on a specific child or select all children, click on the appropriate zone color, then my child`s bracelet should be lighted, matching the color of the zone I have selected. - As a parent, if I didn't choose any of my children then, I shouldn't be able to click on any zone.

11- As a Delegator I want to pick-up the children by notifying the delegated child about my presence, so that the child can leave the school when his bracelet lighted up	5	Feature	Done	<ul style="list-style-type: none"> - As a Delegator, if I go to the arrive page, and click on a specific child or select all children, click on the appropriate zone color, then the child's bracelet should be lighted, matching the color of the zone I have selected. - As a Delegator, if I didn't choose any child then, I shouldn't be able to click on any zone.
12- As a Parent, I want to be able to add a delegator so that he can pick-up my child instead of me.	5	Feature	Done	<ul style="list-style-type: none"> - As a Parent, if I go to the delegation page, click on add delegator, enter delegator information delegation request should be sent to the delegator. - As a Parent, if I go to the delegation page then I should be able to see all delegated users that I have added them.

<p>13- As a Delegator I want to receive a request when the parents want to delegate their children to me so that I can control my delegated student list.</p>	3	Feature	Done	<ul style="list-style-type: none"> - As a Delegator if I received a delegation request, click on reject then the student should not be added to the delegated student list. - As a Delegator if I received a delegation request, click on accept then the student should be added to the delegated student list.
<p>14- As a Parent, I want to be able to delete the delegator so that I can control who can pick-up my child.</p>	3	Feature	Done	<ul style="list-style-type: none"> - As a parent, if I go to the delegation page, click delete, and confirm the deletion, then the delegator should be removed from the list of delegated users, and my child should be removed from the list of delegator's students.

				<ul style="list-style-type: none"> - As a Parent, if I go to the delegation page and click on delete and didn't confirm the deletion then the delegator should still be available on the delegated users list.
15- As an Admin I want to be able to search for student so that I can view student information.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I go to the search page and search for a specific student then I can view student information. - As an Admin, if I go to the search page and search for not existing student then a message indicates that the student does not exist should appear.
16- As an Admin, I want to able to monitor the dashboard so that I can be aware of the daily pick-up process.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if go to dashboard page then I should be able to see the pick-up process details

				<ul style="list-style-type: none"> - As an Admin, if go to dashboard page then I should be able to see If there are any late parents.
17- As an Admin I want to be able to send private announcements to a specific parent so that the parent is aware of any personal matters.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I left any field empty on the private announcement page and click on the “Post” button then a message will appear asking to As an Admin, if I click on the private announcements, and search for non-existent student fill the missing information. - As an Admin, if I write a private announcement and click the “Post” button then the message should be delivered to chosen student parent.

18- As an Admin I want to be able to send a public announcement so that I can inform parents of the most recent school news and updates.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I go to create announcement page and click on create public announcement then I should be able to write a public announcement. - As an Admin, if I click on create public announcement, write an announcement, and click on the “Post” button then the announcement should be published to parents. - As an Admin, if I click on the create public announcement, and left any field empty ,click on the “Post” button then a message will appear asking to fill the missing information.
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19- As a Parent, I want to be able to receive announcement so that I can keep track of the most recent school news and updates.	5	Feature	Done	<ul style="list-style-type: none"> - As a Parent, if I receive a new announcement then it should be added to the announcement in the homepage.
20- As a User I want to be able to login to the application so that I can gain access to Circlight account.	3	Feature		<ul style="list-style-type: none"> - As a User if I enter my email and password correctly and click login, then I should be logged into Circlight account. - As a User if I enter either incorrect email or password and click login, then the login should fail with an error message indicating that the email or password was incorrect.

21-As a User I want to be able to log out so that I can exit my account.	3	Feature	Done	<ul style="list-style-type: none"> - As a User, if I click on the profile icon, click on Log out and confirm the log out, then the data associated to my account shouldn't be accessible and a message will appear confirming that I have logged-out successfully. - As a User, if I click on the profile icon , click on Log out and did not confirm the log out, then I should stay logged in.
21- As a Parent I want to be able to send a request to the school admin so that I can inform the school about an important matter.	5	Feature	Done	<ul style="list-style-type: none"> - As a Parent, If I go to the parent's request page then I can see the requests missing information. - As a Parent if I go to the parent's request page and click on create a requests then I should be able to write a request.

22- As an Admin I want to be able to receive the parent's request, so that I can follow up the needs of parents and students.	3	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I go to the parent's request page then I can see the parent requests that have not been responded on the top of the request list.
23- As an Admin I want to be able to reply to parents' request so that I can inform parents about the request status.	5	Feature	Done	<ul style="list-style-type: none"> - As an Admin, if I go to the parent's request page and select on a request, then I should be able to reply by choose one of the requests` status. - As an Admin, if I go to the parent's request page and select one of the requests, then I should be able to reply by writing some note.
24- As a User I want to be able to edit my profile so that I can keep my profile updated.	3	Feature	Done	<ul style="list-style-type: none"> - As a User if I update my information, then the profile information should be updated.

				<ul style="list-style-type: none"> - As a User if I change my information, then appropriate message should appear to indicate that my information is updated.
25- As a Parent I want to be able to set my status to "late" so that I can inform the school about my latency.	5	Feature	Done	<ul style="list-style-type: none"> - As a Parent if I go to my profile page then I should be able to change my status to "late". - As a Parent, if I click on arrive, then my late status should be back to normal.
26- As a User I want to be able to change my password from my profile, so that I can update my password.	2	Feature	Done	<ul style="list-style-type: none"> - As a User, if I go to my profile page, click on change password, enter my identification and follow the reset password procedure then the new password I entered should be accessible for the next login process.

				<ul style="list-style-type: none"> - As a User if I go to my profile page and click on change password and entered incorrect identification and follow the reset password procedure, then an error message should appear indicating that the entered data is wrong.
27- As a User I want to be able to reset my password from the login page, so that I can change my password if I forget the previous one.	3	Feature	Done	<ul style="list-style-type: none"> - As a User if I go to login page and click on forget password, entered a correct identification data and follow the reset password procedure then the new password I entered should be accessible for the next login process.

				<ul style="list-style-type: none"> - As a User if I go to login page and click on forget password, entered an incorrect identification data, then an error message should appear.
28- As a Parent, I want to be able to receive a notification when the delegator picks up my children so that I can know if my child gets out of school.	3	Feature	Done	<ul style="list-style-type: none"> - As a parent if the delegator picks up my child and I close the app, then I should be able to get a notification.
29- As a Parent, I want to be notified to update my password if it's my first login so that I can remember to change it for my privacy.	3	Feature	Done	<ul style="list-style-type: none"> - As a Parent if I log in at first time then then a page should appear asking me to reset my password.

				- As a Parent, if I don't change the password that admin created, the page appears asking me to reset my password should continue to appear whenever I log in.
Non-Functional Requirements.				
1- Performance:		As a Parent I want to be able to see bracelet to light up for no more than 6 seconds [33] from pressing the arrive button.		
2- Security:		As a user I want to be identified and authenticated so that no one can access my account and get the privileges that assigned to the account [34]		
3- Availability:		As a user I want the Circlight application to be available 10 hours so that I can use it most of the time.		
4- Reliability:		As a user I want the bracelet to light up on correct time with correct color so that I can pick-up the child easily.		
5- Usability	5.1 Satisfaction	As a user, I want to use the application in easy and simple way so that I got satisfied and keep using the application.		
	5.2 Efficiency	As a user, I want to be able to complete tasks in a short amount of time in less than 1 minute so that I can manage pick-up process efficiently [33].		
	5.3 Effectiveness	As a user, I want to be able to complete tasks with an average number of errors 0.7 per task so that I can do what I need effectively [35].		

The non-functional requirements of our application should meet the usability requirements. To understand the usability, in the Appendix G, we will include its definition and how it can be measured.

4.3 System Design

4.3.1 Architectural Diagram

The Circlight system architecture shown in Figure 10 Architecture Diagram it describes all four system layers. Application layer, where various clients are supported, including administration staff, parents, and delegators. Where all the data concerning Admin, Parents, Delegator and Students required to be stored in the cloud at the Data processing layer. The Network layer will connect to the cloud in the Data processing layer through the Wi-Fi technology and it will also be going to control the smart bracelet in the Perception layer in which the smart bracelet contains a NodeMCU which is a highly integrated WiFi System-on-chip.

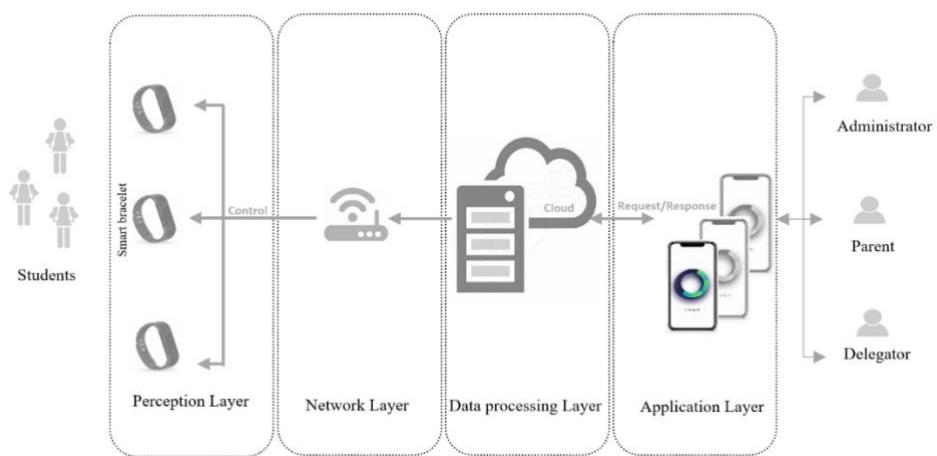


Figure 10 Architecture Diagram

System architecture describes your system's organizational style showing the major subsystems and data repositories and their inter-connections. Include the system architecture and supplement your architecture with text as needed. Provide a high-level overview of how the functionality and responsibilities of the system were partitioned and then assigned to subsystems or components. You may use one of the design patterns, either in describing parts of the architecture, or for referring to elements of the architecture that employ them.

4.3.2 Class Diagram / DFD

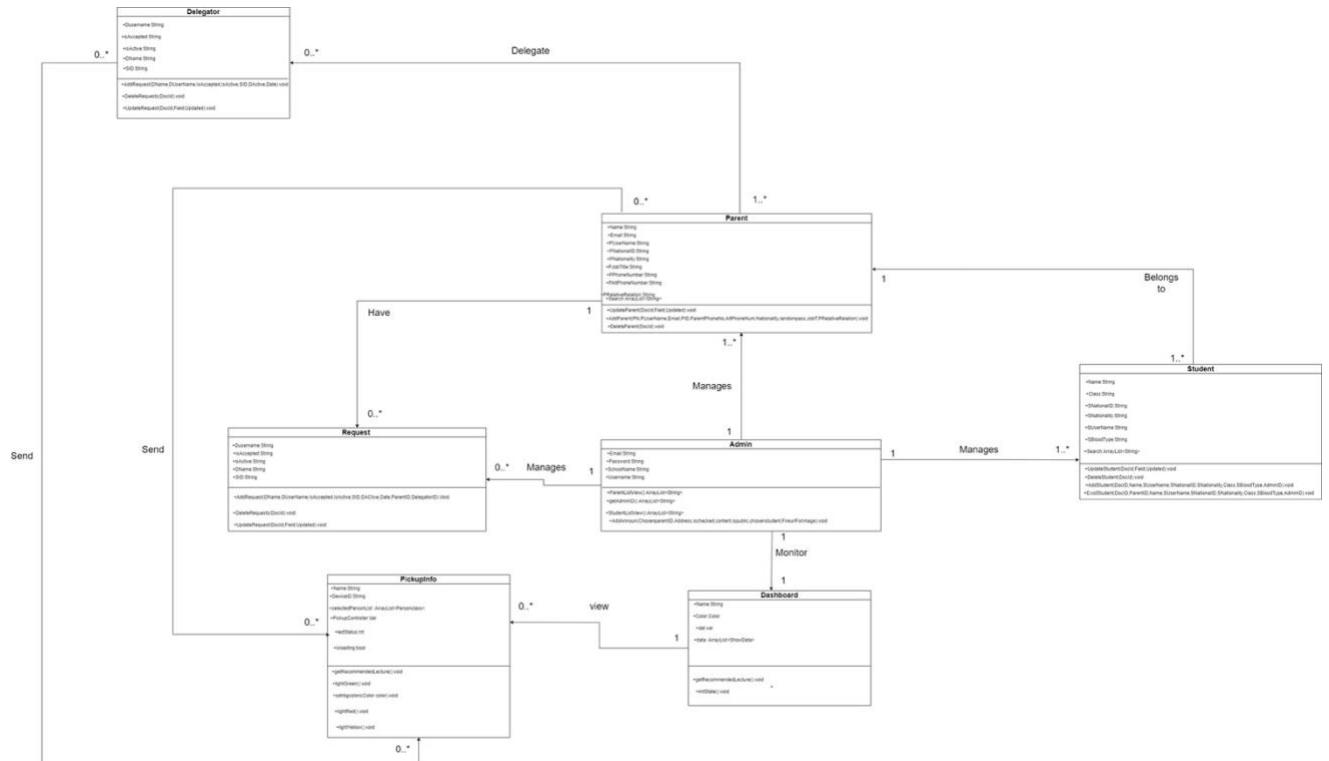


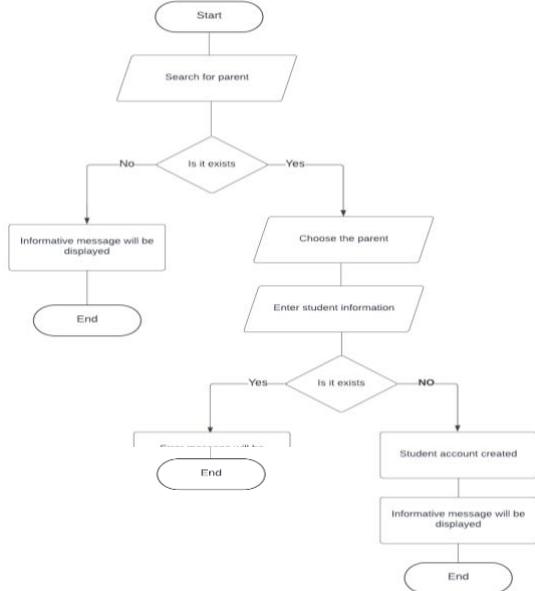
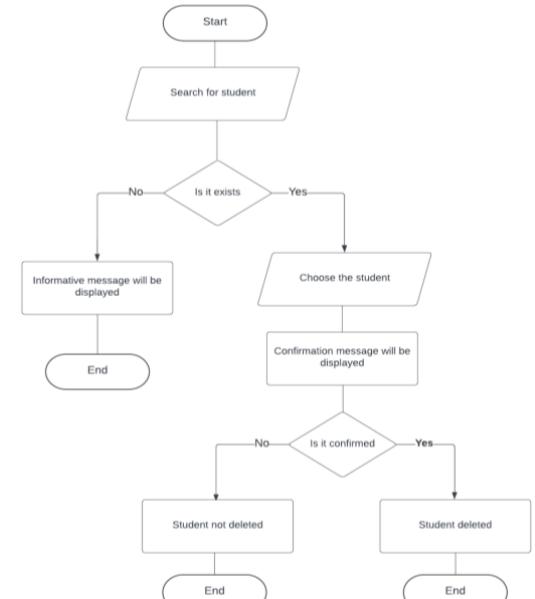
Figure 11 Class Diagram

4.3.3 Component Level Design

This section will present the user story effort and tasks for each of the system components that have been chosen.

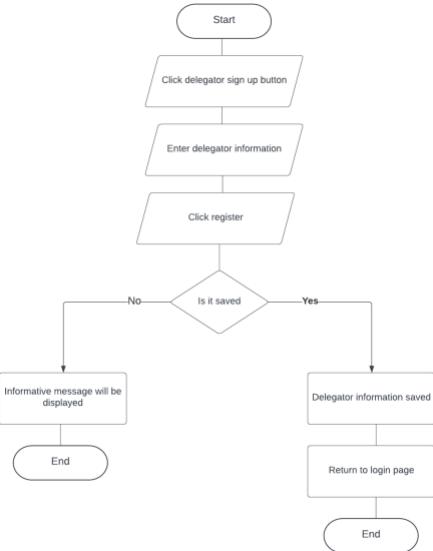
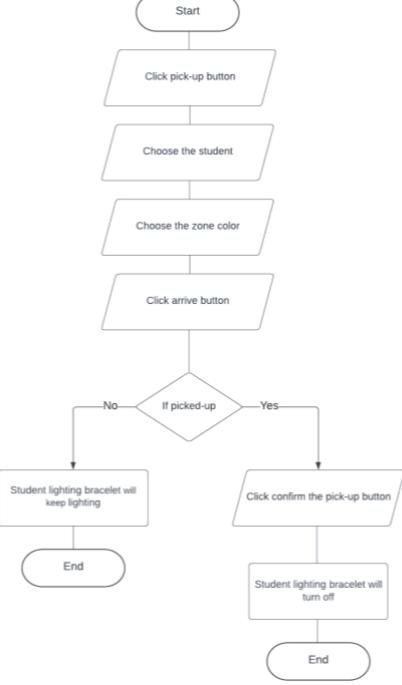
Table 14 Component Level Design

Sprint number	PBI (User story)	flowchart
Sprint 1	As an Admin I want to be able to create a parent account so that he can login to Circlight application.	<pre> graph TD Start([Start]) --> Enter[Enter parent information] Enter --> Decision{Is it exists} Decision -- No --> Account[Account created] Account --> Message1[Informative message will be displayed] Message1 --> End1([End]) Decision -- Yes --> Error[Error message will be displayed] Error --> End2([End]) </pre> <p><i>Figure 12 create a parent account</i></p>
Sprint 1	As an Admin I want to be able to share the created parent account (username – password) in non-paper-based method so that he can gain access to his account.	<pre> graph TD Start([Start]) --> Enter[Enter parent information] Enter --> Decision{Is it exists} Decision -- No --> Account[Account created] Account --> Message1[Informative message will be displayed] Message1 --> Share[Share created parent account] Share --> End1([End]) Decision -- Yes --> Error[Error message will be displayed] Error --> End2([End]) </pre> <p><i>Figure 13 share the created parent account</i></p>

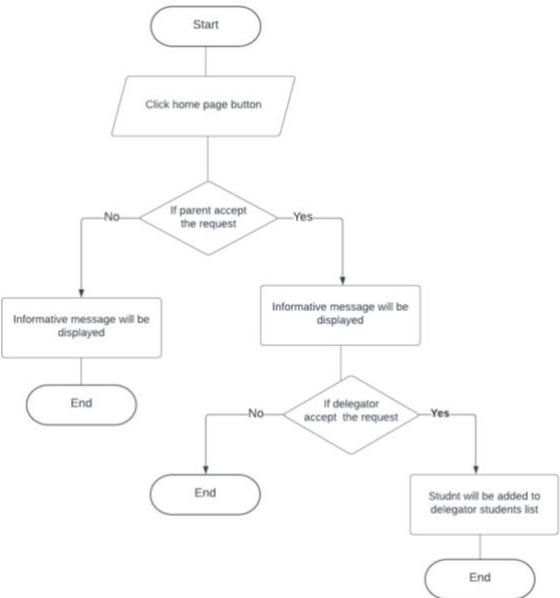
Sprint 1	<p>As an Admin I want to be able to assign students to their parent so that I can connect them together.</p>	 <pre> graph TD Start((Start)) --> Search[Search for parent] Search --> Decision{Is it exists} Decision -- No --> Message1[Informative message will be displayed] Message1 --> End1(((End))) Decision -- Yes --> Choose[Choose the parent] Choose --> Enter[Enter student information] Enter --> Decision2{Is it exists} Decision2 -- Yes --> Message2[Informative message will be displayed] Message2 --> End2(((End))) Decision2 -- No --> Create[Student account created] Create --> Message3[Informative message will be displayed] Message3 --> End3(((End))) </pre> <p><i>Figure 14 assign students to their parent</i></p>
Sprint 1	<p>As an Admin I want to be able to delete students so that I can remove students who are no longer registered in school.</p>	 <pre> graph TD Start((Start)) --> Search[Search for student] Search --> Decision{Is it exists} Decision -- No --> Message1[Informative message will be displayed] Message1 --> End1(((End))) Decision -- Yes --> Choose[Choose the student] Choose --> Confirmation[Confirmation message will be displayed] Confirmation --> Decision2{Is it confirmed} Decision2 -- No --> NotDeleted[Student not deleted] NotDeleted --> End2(((End))) Decision2 -- Yes --> Deleted[Student deleted] Deleted --> End3(((End))) </pre> <p><i>Figure 15 delete students</i></p>

Sprint 1	<p>As an Admin I want to be able to delete the parent so that I can remove parents that their children are no longer registered in school.</p>	<pre> graph TD Start([Start]) --> Search[Search for parent] Search --> IsExists{Is it exists} IsExists -- No --> Info1[Informative message will be displayed] Info1 --> End1([End]) IsExists -- Yes --> Choose[Choose the parent] Choose --> Info2[Confirmation message will be displayed] Info2 --> IsConfirmed{Is it confirmed} IsConfirmed -- No --> ParentNotDeleted[Parent not deleted] ParentNotDeleted --> End2([End]) IsConfirmed -- Yes --> ParentDeleted[Parent deleted] ParentDeleted --> End3([End]) </pre> <p><i>Figure 16 delete parent</i></p>
Sprint 1	<p>As an Admin I want to be able to update the parent's information so that I can keep the parent data up to date.</p>	<pre> graph TD Start([Start]) --> Search[Search for parent] Search --> IsExists{Is it exists} IsExists -- No --> Info1[Informative message will be displayed] Info1 --> End1([End]) IsExists -- Yes --> Choose[Choose the parent] Choose --> Update[Update parent information] Update --> IsSaved{Is it saved} IsSaved -- No --> ContinueEditing[Continue editing] ContinueEditing --> End2([End]) IsSaved -- Yes --> Updated[Parent information updated] Updated --> Return[Return to parent list page] Return --> Info2[Informative message will be displayed] Info2 --> End3([End]) </pre> <p><i>Figure 17 update the parent's information</i></p>

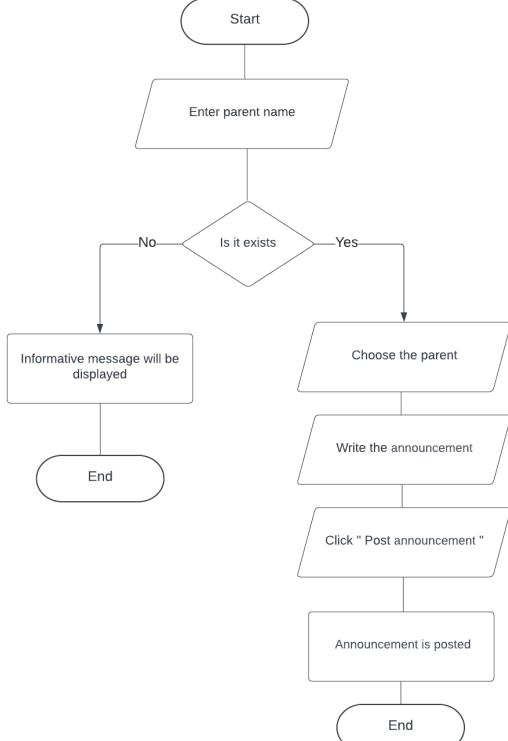
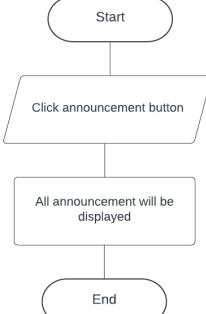
Sprint 1	<p>As an Admin I want to be able to update student information so that I can keep the student data up to date.</p>	<pre> graph TD Start([Start]) --> Search[Search for student] Search --> Decision{Is it exists} Decision -- No --> Message1[Informative message will be displayed] Message1 --> End1([End]) Decision -- Yes --> Choose[Choose the student] Choose --> Update[Update student information] Update --> Decision2{Is it saved} Decision2 -- No --> Discard{Is it discarded} Discard -- No --> Continue[Continue editing] Continue --> End2([End]) Discard -- Yes --> Return1[Return to student list page] Return1 --> End3([End]) Decision2 -- Yes --> Updated[Student information updated] Updated --> Message2[Informative message will be displayed] Message2 --> End4([End]) </pre> <p><i>Figure 18 update student information</i></p>
Sprint 2	<p>As an Admin I want to be able to reassign the student so that I can correct my mistake if I assign the student to an incorrect parent.</p>	<pre> graph TD Start([Start]) --> Search[Search for student] Search --> Decision{Is it exists} Decision -- No --> Message1[Informative message will be displayed] Message1 --> End1([End]) Decision -- Yes --> Choose[Choose the student] Choose --> Assign[choose the correct parent] Assign --> Decision2{Is it saved} Decision2 -- No --> Return1[Return to student list page] Return1 --> End2([End]) Decision2 -- Yes --> Updated[student information updated] Updated --> Message2[Informative message will be displayed] Message2 --> End3([End]) </pre> <p><i>Figure 19 to reassign the student</i></p>

Sprint 2	<p>As a Delegator I want to be able to register so that I can use Circlight application.</p>	 <pre> graph TD Start([Start]) --> Click[Click delegator sign up button] Click --> Enter[Enter delegator information] Enter --> Register[Click register] Register --> Decision{Is it saved} Decision -- No --> Message[Informative message will be displayed] Message --> End([End]) Decision -- Yes --> Saved[Delegator information saved] Saved --> Login[Return to login page] Login --> End </pre> <p><i>Figure 20 Delegator register</i></p>
Sprint 2	<p>As a Parent I want to pick-up my child by notifying him about my presence, so that my child can leave the school when his bracelet lighted up.</p>	 <pre> graph TD Start([Start]) --> Click[Click pick-up button] Click --> ChooseStudent[Choose the student] ChooseStudent --> ChooseColor[Choose the zone color] ChooseColor --> ClickArrive[Click arrive button] ClickArrive --> Decision{If picked-up} Decision -- No --> Lighting[Student lighting bracelet will keep lighting] Lighting --> End([End]) Decision -- Yes --> Confirm[Click confirm the pick-up button] Confirm --> TurnOff[Student lighting bracelet will turn off] TurnOff --> End </pre> <p><i>Figure 21 Parent pick-up</i></p>

Sprint 2	<p>As a Delegator I want to pick-up the children by notifying the delegated child about my presence, so that the child can leave the school when his bracelet lighted up.</p>	<pre> graph TD Start([Start]) --> ClickPickUp[Click pick-up button] ClickPickUp --> ChooseStudent[Choose the student] ChooseStudent --> ChooseZoneColor[Choose the zone color] ChooseZoneColor --> ClickArrive[Click arrive button] ClickArrive --> IfPickedUp{If picked-up} IfPickedUp -- No --> StudentLighting[Student lighting bracelet will keep lighting] IfPickedUp -- Yes --> ClickConfirm[Click confirm the pick-up button] StudentLighting --> End([End]) ClickConfirm --> StudentTurnOff[Student lighting bracelet will turn off] StudentTurnOff --> End </pre> <p><i>Figure 22 Delegator pick-up</i></p>
Sprint 2	<p>As a Parent, I want to be able to add a delegator so that he can pick-up my child instead of me.</p>	<pre> graph TD Start([Start]) --> ClickDelegators[Click the delegators list page] ClickDelegators --> ClickRequests[Click requests] ClickRequests --> ClickAdd[Click add button] ClickAdd --> WriteUsername[Write delegator username] WriteUsername --> ChooseStudent[Choose the student] ChooseStudent --> ClickDelegate[Click delegate] ClickDelegate --> ConfirmationMessage[Confirmation message will displayed] ConfirmationMessage --> End([End]) </pre> <p><i>Figure 23 Add a delegator</i></p>

Sprint 2	<p>As a Delegator I want to receive a request when the parents want to delegate their children to me so that I can control my delegated student list.</p>	 <pre> graph TD Start([Start]) --> Click[Click home page button] Click --> Decision1{If parent accept the request} Decision1 -- No --> Message1[Informative message will be displayed] Message1 --> End1([End]) Decision1 -- Yes --> Message2[Informative message will be displayed] Message2 --> Decision2{If delegator accept the request} Decision2 -- No --> End2([End]) Decision2 -- Yes --> AddStudent[Student will be added to delegator students list] AddStudent --> End3([End]) </pre> <p><i>Figure 24 Delegator receive a request from parent</i></p>
Sprint 2	<p>As a Parent, I want to be able to delete the delegator so that I can control who can pick-up my child.</p>	 <pre> graph TD Start([Start]) --> Click[Click the delegators list page] Click --> Search[Search for delegator] Search --> Decision{Is it exists} Decision -- No --> Message1[Informative message will be displayed] Message1 --> End1([End]) Decision -- Yes --> Delete[Delete the delegator] Delete --> Message2[Delegator request is deleted] Message2 --> End2([End]) </pre> <p><i>Figure 25 Delete the delegator</i></p>

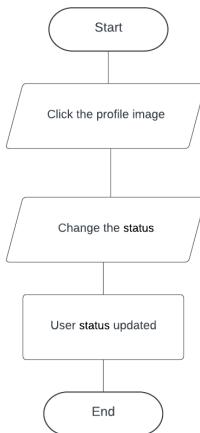
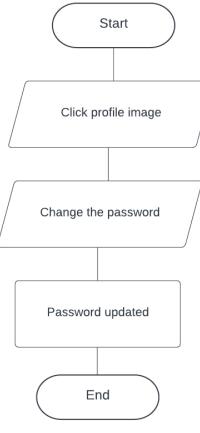
Sprint 2	<p>As an Admin I want to be able to search for student so that I can view student information.</p>	<pre> graph TD Start([Start]) --> Enter[Enter student name] Enter --> Decision{Is it exists} Decision -- No --> Message[Informative message will be displayed] Message --> End([End]) Decision -- Yes --> Student[Student information is shown] Student --> End </pre> <p><i>Figure 26 search for student</i></p>
Sprint 3	<p>As an Admin, I want to be able to monitor the dashboard so that I can be aware of the daily pick-up process.</p>	<pre> graph TD Start([Start]) --> Click[Click Dashboard button] Click --> Dashboard[Dashboard information is displayed] Dashboard --> End([End]) </pre> <p><i>Figure 27 monitor the dashboard</i></p>
Sprint 3	<p>As an Admin I want to be able to send private announcements to a specific parent so that the parent is aware of any personal matters.</p>	<pre> graph TD Start([Start]) --> Click[Click announcement button] Click --> Write[Write the announcement title] Write --> ClickParent[Click on specific parent] ClickParent --> SetImportance[Set the flag of the importance] SetImportance --> ClickPost[Click "Post announcement"] ClickPost --> Posted[Announcement is posted] Posted --> End([End]) </pre> <p><i>Figure 28 send private announcements</i></p>

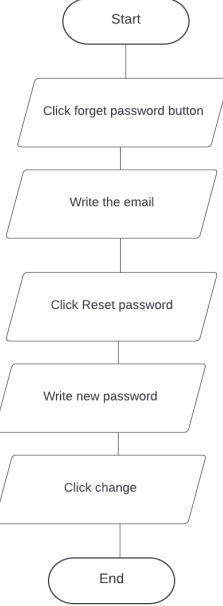
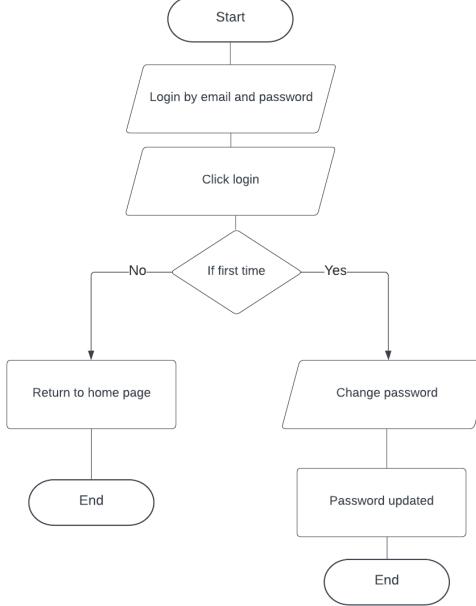
Sprint 3	<p>As an Admin I want to be able to send a public announcement so that I can inform parents of the most recent school news and updates.</p>	 <pre> graph TD Start([Start]) --> Enter[Enter parent name] Enter --> Decision{Is it exists} Decision -- No --> Message[Informative message will be displayed] Message --> End([End]) Decision -- Yes --> Choose[Choose the parent] Choose --> Write[Write the announcement] Write --> Post[Click "Post announcement"] Post --> Posted[Announcement is posted] Posted --> End </pre> <p><i>Figure 29 send a public announcement</i></p>
Sprint 3	<p>As a Parent, I want to be able to receive announcement so that I can keep track of the most recent school news and updates.</p>	 <pre> graph TD Start([Start]) --> Click[Click announcement button] Click --> Display[All announcement will be displayed] Display --> End([End]) </pre> <p><i>Figure 30 receive announcement</i></p>

Sprint 4	<p>As a User I want to be able to login to the application so that I can gain access to Circlight account.</p>	<pre> graph TD Start([Start]) --> Enter[Enter the Email and the password] Enter --> Decision{Is it exists} Decision -- No --> Informative[Informative message will be displayed] Informative --> End1([End]) Decision -- Yes --> Success[The user loged in successfully] Success --> End2([End]) </pre> <p><i>Figure 31 login to the application</i></p>
Sprint 4	<p>As a User I want to be able to log out so that I can exit my account.</p>	<pre> graph TD Start([Start]) --> Click[Click the log out button] Click --> Confirmation[Confirmation message will be displayed] Confirmation --> Decision2{If user want to log out} Decision2 -- No --> Stay[The user will stay logged in] Stay --> End3([End]) Decision2 -- Yes --> Success2[The user loged out successfully] Success2 --> End4([End]) </pre> <p><i>Figure 32 log out</i></p>

Sprint 4	<p>As a Parent I want to be able to send a request to the school admin so that I can inform the school about an important matter.</p>	<pre> graph TD Start([Start]) --> ClickRequest[Click request button] ClickRequest --> AddRequest[Click (+) to add new request] AddRequest --> ChooseStudent[Choose the student] ChooseStudent --> WriteRequest[Write the request] WriteRequest --> UploadAttachment[Upload the attachment] UploadAttachment --> ClickSend[Click send request] ClickSend --> Confirmation[Confirmation message will be displayed] Confirmation --> End([End]) </pre> <p><i>Figure 33 send a request to the school admin</i></p>
Sprint 4	<p>As an Admin I want to be able to receive the parents' request, so that I can follow up the needs of parents and students.</p>	<pre> graph TD Start([Start]) --> ClickRequest[Click on request button] ClickRequest --> Requests[All requests will appear] Requests --> Decision{If in progress} Decision -- NO --> Review[Review the request information by the admin] Review --> End([End]) Decision -- YES --> Response[The admin will response to the request] Response --> End([End]) </pre> <p><i>Figure 34 receive the parent's request</i></p>

Sprint 4	<p>As an Admin I want to be able to reply to parents' request so that I can inform parents about the request status.</p>	<pre> graph TD Start([Start]) --> Click1[Click the requests page] Click1 --> Click2[Click specific request] Click2 --> Info[Request information will be displayed] Info --> Comment[The admin will write a comment] Comment --> Status[Choose the status of the request (accepted - rejected - incomplete)] Status --> Send[Click send] Send --> Confirmation[Confirmation message will be displayed] Confirmation --> End([End]) </pre> <p><i>Figure 35 Admin reply to parents' request</i></p>
Sprint 4	<p>As a User I want to be able to edit my profile so that I can keep my profile updated.</p>	<pre> graph TD Start([Start]) --> Click1[Click the profile image] Click1 --> Edit[Edit the user information] Edit --> Decision1{Is it saved} Decision1 -- No --> Decision2{Is it discarded} Decision2 -- No --> End([End]) Decision2 -- Yes --> Update[User information updated] Update --> Message[Informative message will be displayed] Message --> End([End]) Decision1 -- Yes --> End([End]) </pre> <p><i>Figure 36 edit my profile</i></p>

Sprint 4	<p>As a Parent I want to be able to set my status to "late" so that I can inform the school about my latency.</p>	 <pre> graph TD Start([Start]) --> Click[Click the profile image] Click --> Change[Change the status] Change --> Updated[User status updated] Updated --> End([End]) </pre> <p><i>Figure 37 set my status to "late"</i></p>
Sprint 4	<p>As a User I want to be able to change my password from my profile, so that I can update my password.</p>	 <pre> graph TD Start([Start]) --> Click[Click profile image] Click --> Change[Change the password] Change --> Updated[Password updated] Updated --> End([End]) </pre> <p><i>Figure 38 change my password from my profile</i></p>

Sprint 4	<p>As a User I want to be able to reset my password from the login page, so that I can change my password if I forget the previous one.</p>	 <pre> graph TD Start([Start]) --> ClickForget[Click forget password button] ClickForget --> WriteEmail[Write the email] WriteEmail --> ClickReset[Click Reset password] ClickReset --> WriteNewPass[Write new password] WriteNewPass --> ClickChange[Click change] ClickChange --> End([End]) </pre> <p><i>Figure 39 reset my password from the login page</i></p>
Sprint 4	<p>As a Parent, I want to be notified to update my password if it's my first login so that I can remember to change it for my privacy.</p>	 <pre> graph TD Start([Start]) --> Login[Login by email and password] Login --> ClickLogin[Click login] ClickLogin --> IfFirstTime{If first time} IfFirstTime -- No --> ReturnHome[Return to home page] IfFirstTime -- Yes --> ChangePass[Change password] ChangePass --> PasswordUpdated[Password updated] ReturnHome --> End([End]) PasswordUpdated --> End([End]) </pre> <p><i>Figure 40 want to be notified to update my password</i></p>

4.4 Data Design

4.4.1 Data Model

- The ER diagram

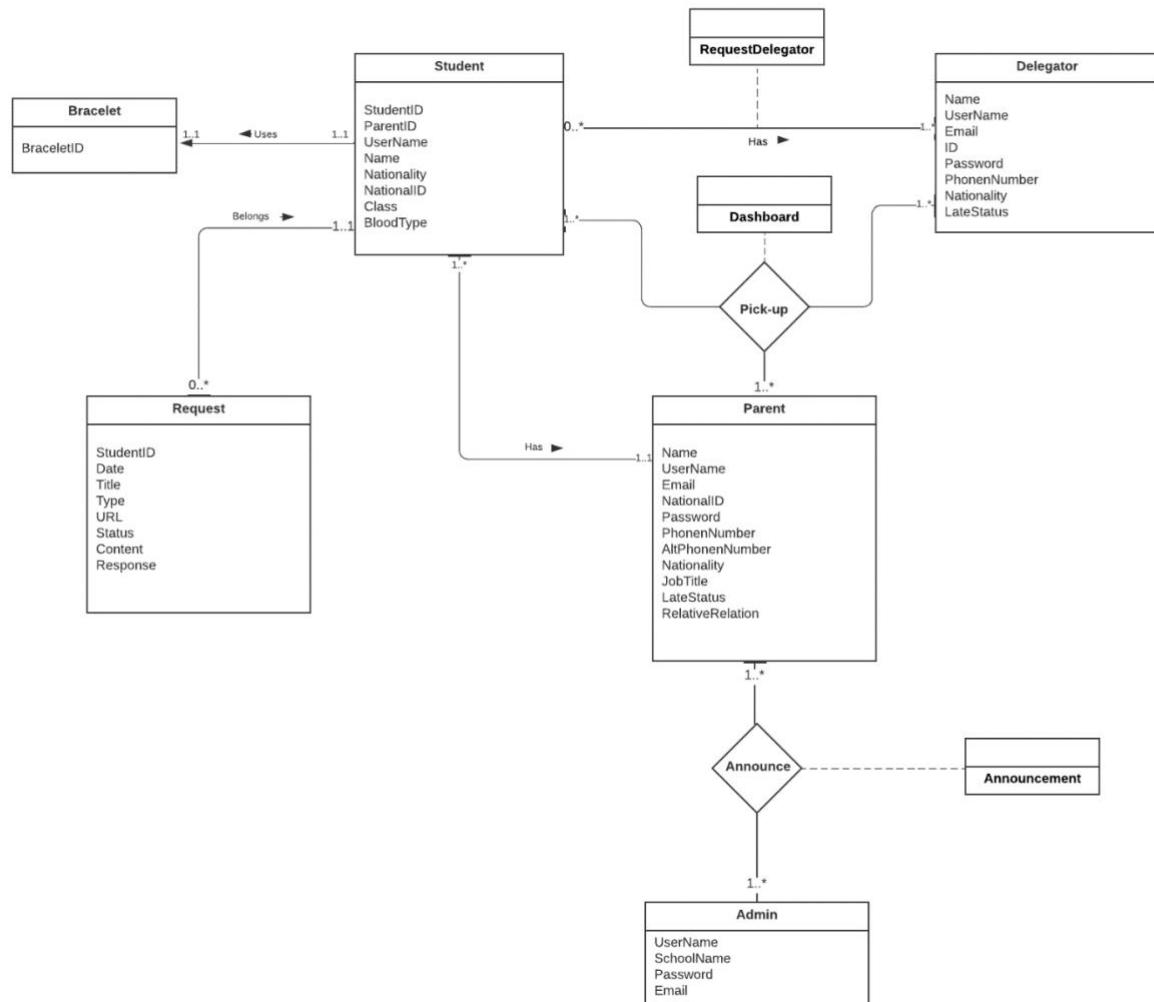


Figure 41 ER Diagram

4.4.2 Data model

This section provides the non-functional data model for Circlight application in Figure 42.

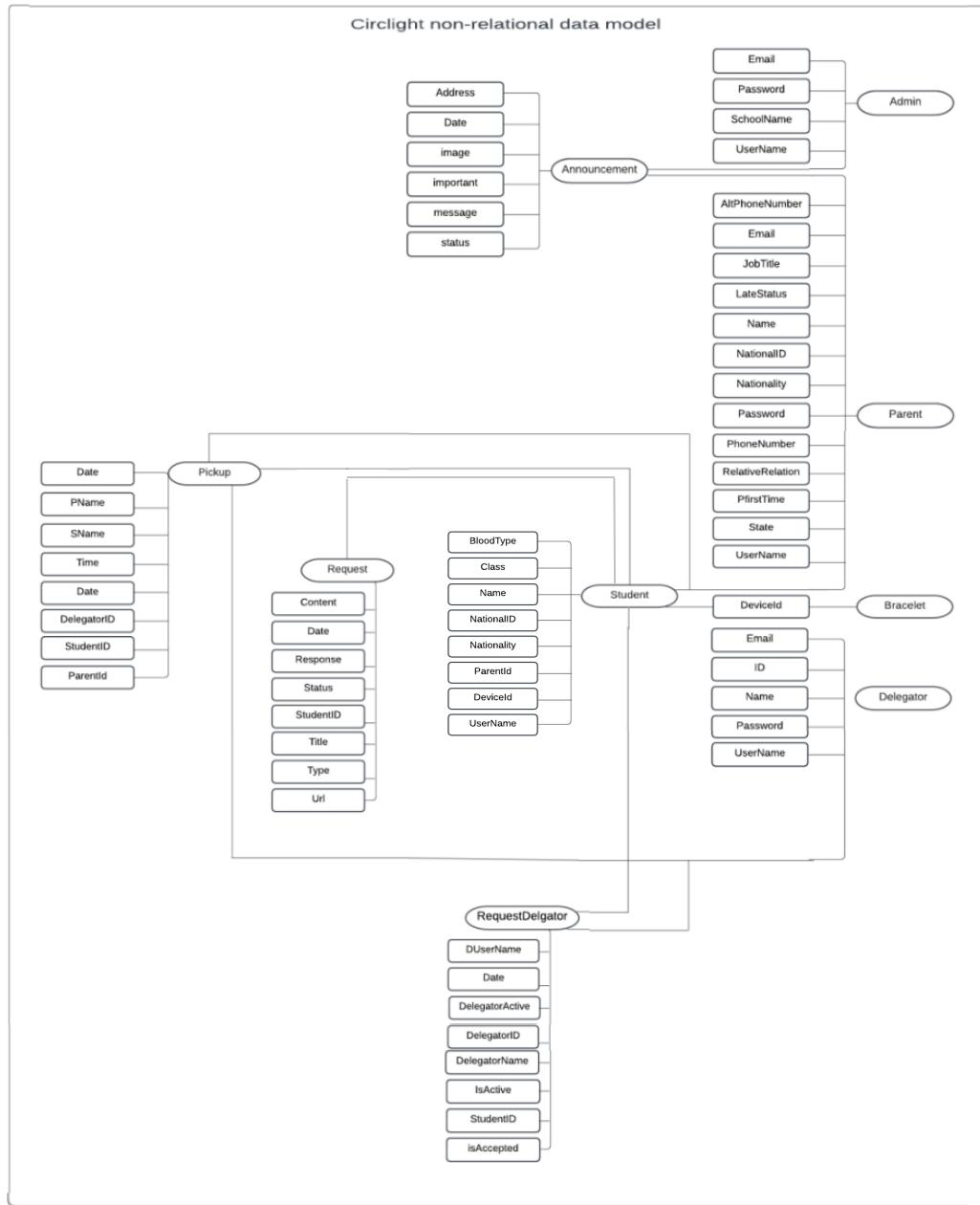


Figure 42 Non-Functional Data Model

4.5 Interface Design

The following UX guidelines are used to improve user interactions [36]:

- **Match between the system with the real world**, we provide a simple interface by using a footer navigation bar. terms, icons, and images correspond to predictable outcomes.
- **Aesthetic and Minimalist user interface design**, we tried to eliminate user confusion by adopting familiar icons.
- **Consistency**, for a better user experience and to reduce distraction, we provide a consistent interface by adopting contrasting colors in the system background, buttons, and fields.
- **Error Prevention**, we provide error prevention and error handling methods.
- **Recognition rather than recall**, elements and options is visible and easily retrievable throughout the application.

4.5.1 Users interfaces

- Home page



#	Description
1	Button to login page for all users.
2	Button to register page for the delegator.

- Login Page

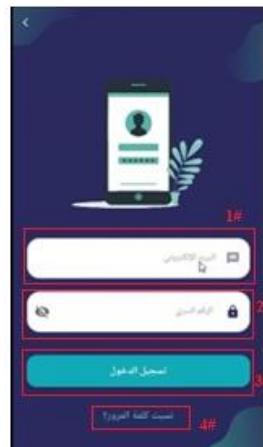


Figure 44 Login Page

Table 16 Login Page

#	Description
1	Field to write the email.
2	Field to write the password.
3	Button to login page.
4	Button for forget password page.

- Forget password Page

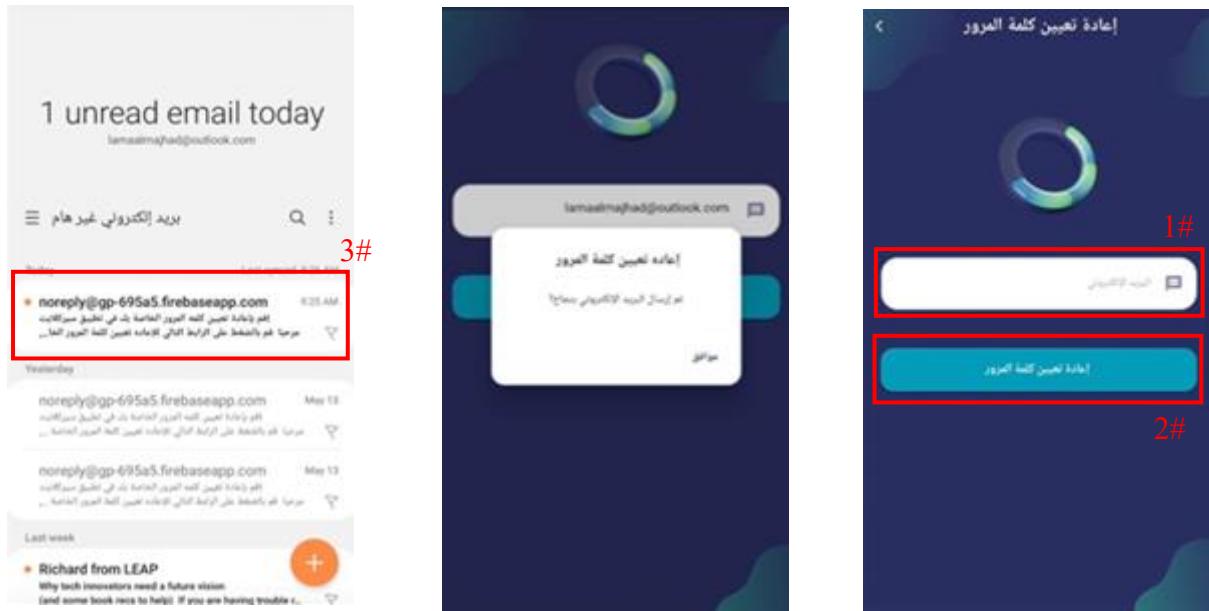


Figure 45 Reset Password Page

Table 17 Reset Password Page

#	Description
1	Field to write the email.
2	Button to send an email.
3	Email to reset the password.

4.5.1 Admin Pages

- Main admin page



Figure 46 Main admin page

Table 18 Main admin page

#	Description
1	Button for edit profile page
2	Button to manage the student page
3	Button to manage the parent page
4	Button for main page
5	Button for manage the dashboard page
6	Button for announcements page
7	Button for search student page
8	Button for requests page

- Admin Edit Profile Page

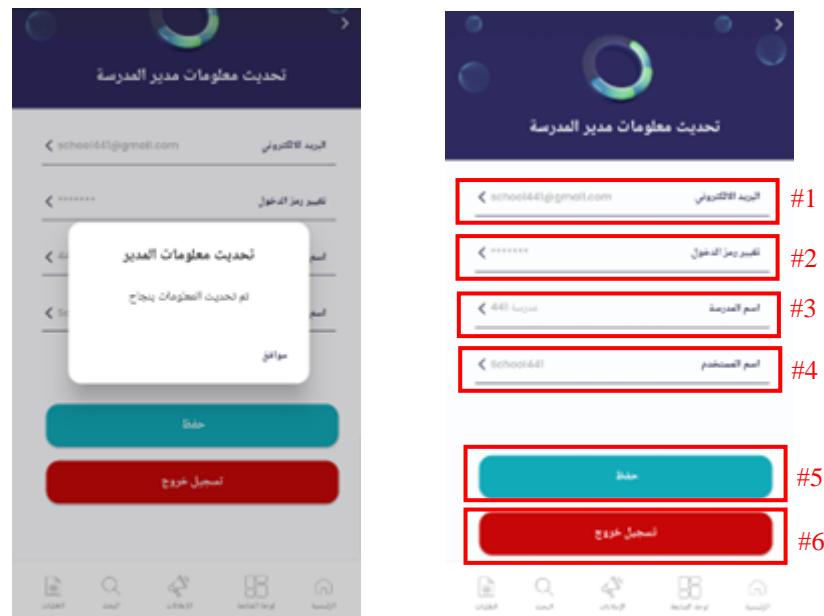


Figure 47 Admin Edit Profile Page

Table 19 Admin Edit Profile Page

#	Description
1	Button to edit the email.
2	Button to edit the password.
3	Button to edit the school's name.
4	Button to edit the username.
5	Button to save the changes.
6	Button to log out.

- Manage Student Page



Figure 48 Manage Student Page

Table 20 Manage Student Page

#	Description
1	Button for edit profile page
2	Button to search for student
3	Button to reassign the student
4	Button to update the student information
5	Button to delete the student

- Manage Parent Page



Figure 49 Manage Parent Page

Table 21 Manage Parent Page

#	Description
1	Button for edit profile page
2	Button to search for parent
3	Button to create the parent account
4	Button to assign the student to parent page
5	Button to update the parent information page
6	Button to delete the parent page

- Manage Announcements Page



Figure 50 Manage Announcements Page

Table 22 Manage Announcements Page

#	Description
1	Button for edit profile page
2	Button for the private announcement page
3	Button for the public announcement page
4	Button for search
5	Button to create a new announcement
6	Announcements area

- Manage Requests Page



Figure 51 Manage Requests Page

Table 23 Manage Requests Page

#	Description
1	Button for edit profile page
2	Button for search
3	Current requests area
4	Previous requests area

- Manage The Dashboard



Figure 52 Manage The Dashboard

Table 24 Manage The Dashboard

#	Description
1	Button for edit profile page
2	Button for late parents or delegators page
3	Button for students' pick-up page
4	Students' pick-up information area
5	List of late parents or delegators information area

- General Search For Student

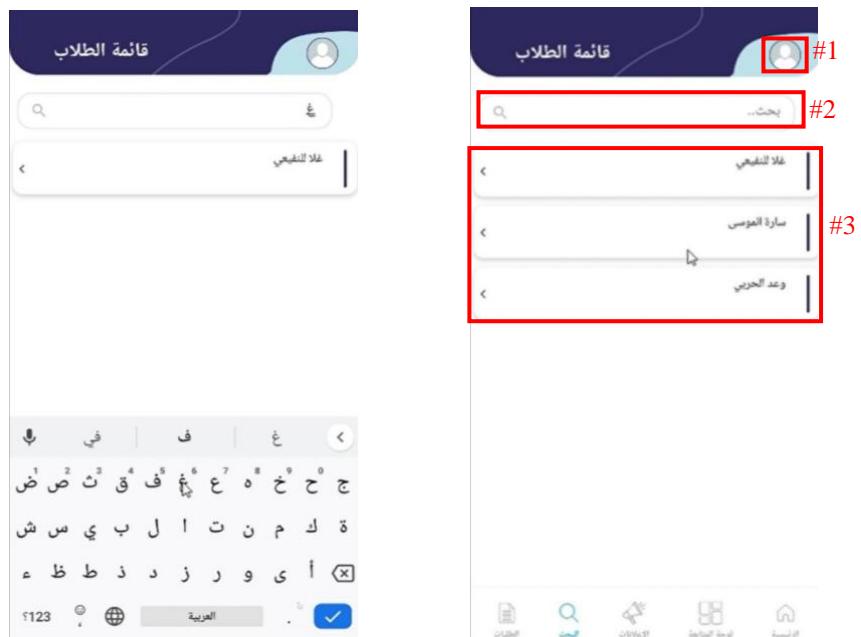


Figure 53 General Search For Student

Table 25 General Search For Student

#	Description
1	Button for edit profile page
2	Button to search for student
3	Students profile area

4.5.2 Parent Pages

- Parent Home Page



Figure 54 Parent Home Page

Table 26 Parent Home Page

#	Description
1	Button for edit profile page
2	Recent announcements area
3	Button for main page
4	Button for the delegators list page
5	Button for the student pick-up page
6	Button for announcements page
7	Button for requests page

- Parent Edit Profile

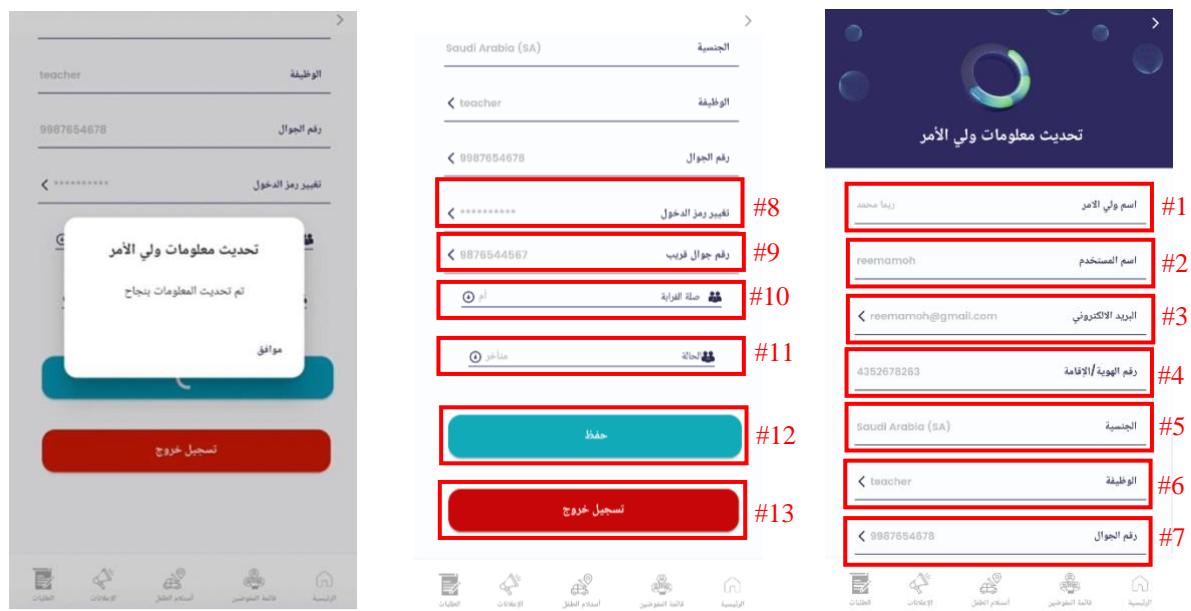


Figure 55 Parent Edit Profile

Table 27 Parent Edit Profile

#	Description
1	Button for parent name (Cannot be edited)
2	Button for parent username (Cannot be edited)
3	Button for parent Email (Can be edited)
4	Button for parent national ID (Cannot be edited)
5	Button for parent nationality (Cannot be edited)
6	Button for parent job title (Can be edited)
7	Button for parent phone number (Can be edited)
8	Button for parent password (Can be edited)
9	Button for alternative phone number (Can be edited)
10	Button for Relative relationship
11	Button for late status
12	Button to save the changes
13	Button to log out

- Delegators List Page



Figure 56 Delegators List Page

Table 28 Delegators List Page

#	Description
1	Button for edit profile page
2	Button for delegation requests
3	Button for delegators
4	Button for search
5	Button for deactivate all delegators
6	Available delegators area
7	Unavailable delegators area
8	Button to deactivate and activate specific delegator
9	Button to add the delegator
10	InProgress delegation requests area
11	Accepted delegation requests area
12	Rejected delegation requests area
13	Button to delete the delegator

- Parent Pick-up Page



Figure 57 Parent Pick-up Page

Table 29 Parent Pick-up Page

#	Description
1	Button for edit profile page
2	List of students to pick them up
3	Buttons for colored zones

- Parent Announcements Page

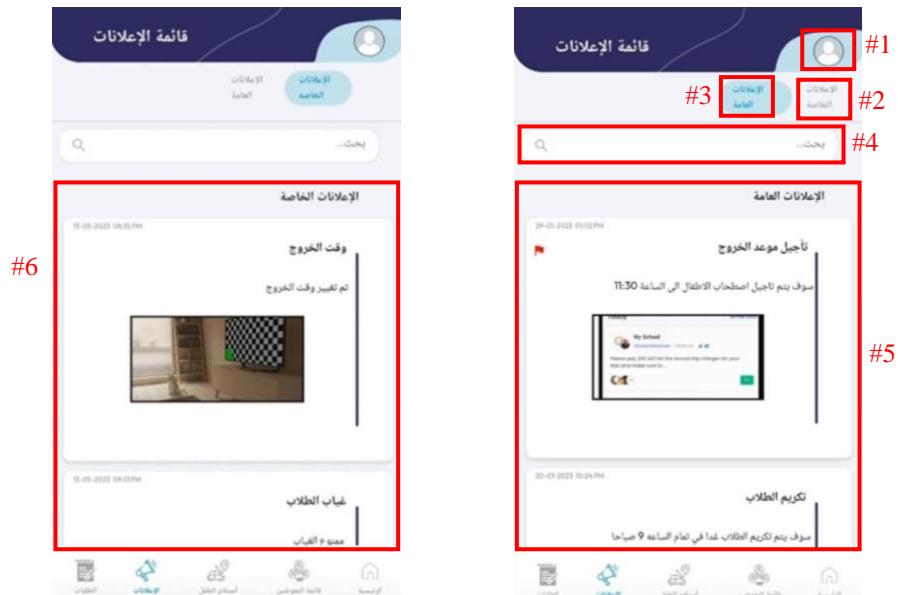


Figure 58 Parent Announcements Page

Table 30 Parent Announcements Page

#	Description
1	Button for edit profile page
2	Button for private announcements page
3	Button for public announcements page
4	Button for search
5	Public announcements area
6	Private announcements area

- Requests Page



Figure 59 Requests Page

Table 31 Requests Page

#	Description
1	Button for edit profile page
2	Button for search
3	Button to add new request
4	Current requests area
5	Previous requests area

4.5.3 Delegator Pages

- Delegator registration Page

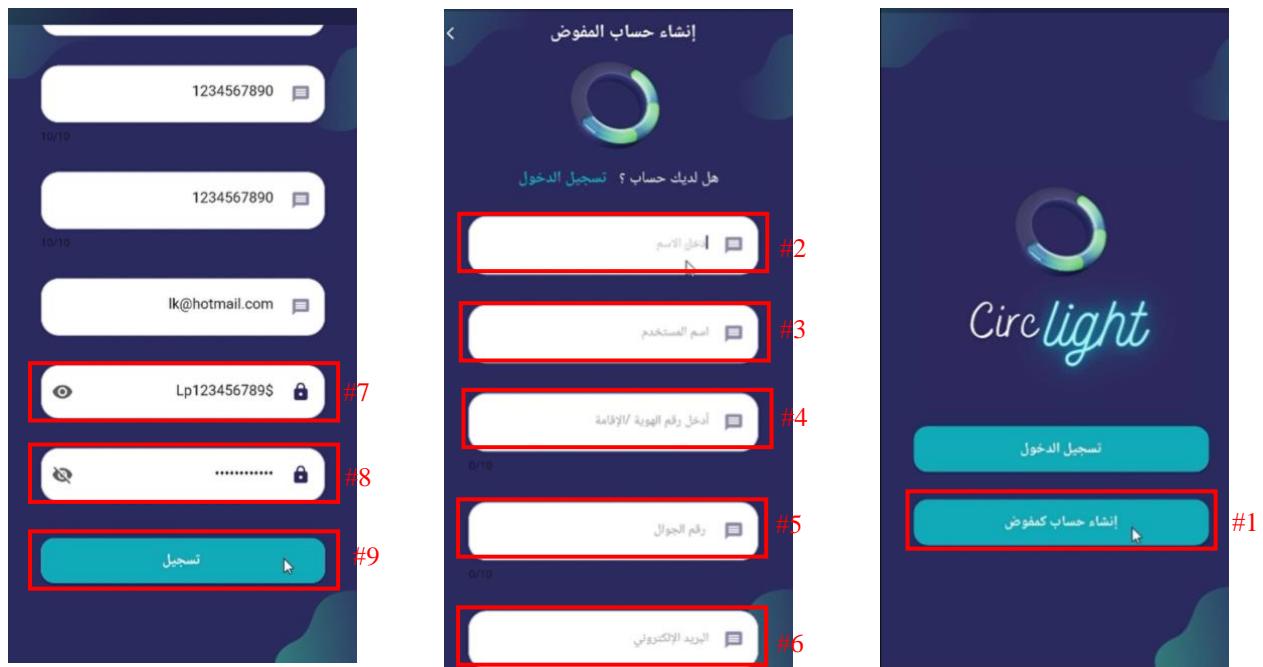


Figure 60 Delegator registration Page

Table 32 Delegator registration Page

#	Description
1	Button for delegator registration page
2	Field for delegator name
3	Field for delegator username
4	Field for delegator national ID
5	Field for delegator phone number
6	Field for delegator email
7	Field for delegator password
8	Field for password confirmation
9	Button for registration

- Delegator Home Page

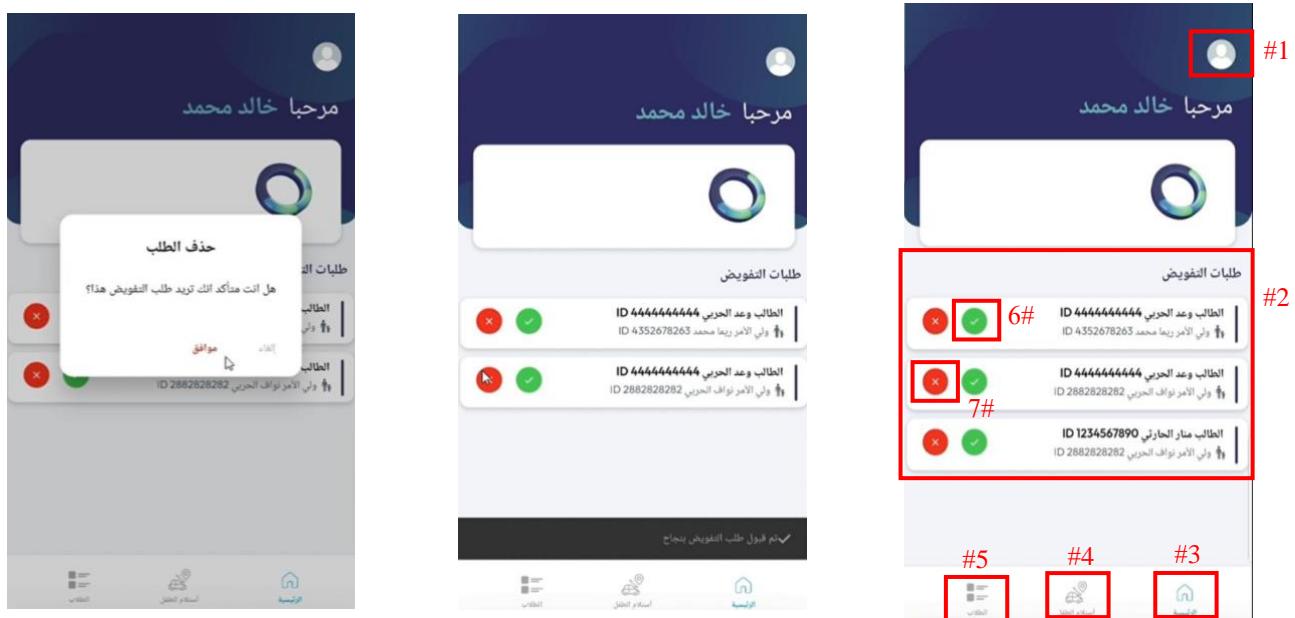


Figure 61 Delegator Home Page

Table 33 Delegator Home Page

#	Description
1	Button for edit profile page
2	Delegation requests area
3	Button for main page
4	Button for the student pick-up page
5	Button for the delegated students
6	Button for accept the delegation request
7	Button for reject the delegation request

- Delegator Edit Profile

The screenshot shows a profile editing form titled "تحديث معلومات المفوض" (Update Profile Information). The form contains the following fields:

- #1: Name field (الاسم) containing "خالد محمد".
- #2: Username field (اسم المستخدم) containing "khalidmoh".
- #3: Email field (البريد الإلكتروني) containing "khalidmoh@gmail.com".
- #4: National ID field (رقم الهوية/الإقامة) containing "٩١٢٧٤٧٤٧٥".
- #5: Password field (تفصير رمز الدخول) containing "*****".
- #6: Status field (الحالة) with a dropdown menu showing "مفعل" (Enabled).
- #7: Save button (حفظ) in a teal bar.
- #8: Log out button (تسجيل خروج) in a red bar.

Figure 62 Delegator Edit Profile

Table 34 Delegator Edit Profile

#	Description
1	Field for delegator name
2	Field for delegator username
3	Field for delegator email
4	Field for delegator national ID
5	Field for delegator password
6	Field for late status
7	Button for save the changes
8	Button for log out

- Delegator Pick-up Page



Figure 63 Delegator Pick-up Page

Table 35 Delegator Pick-up Page

#	Description
1	Button for edit profile page
2	List of students to pick them up
3	Buttons for colored zones

- ## - Delegated Students Page



Figure 64 Delegated Students Page

Table 36 Delegated Students Page

#	Description
1	Button for edit profile page
2	Button for search
3	Button for deactivate all delegated students
4	Delegated students' area
5	Temporarily suspended request from parent area
6	Button for activate and deactivate the delegation

4.6 System Implementation

This section explains the Circlight system's implementation procedures in addition to the major functions' components and code-segments. There are three subsections, which include hardware components, software components, and implementation difficulties. According to the proposed architecture of the Circlight system as shown on Figure 65, there are different phases that need to be considered in the implementation, which are: configuring the smart bracelet, developing IoT control application, deploying the database, and developing the mobile application.

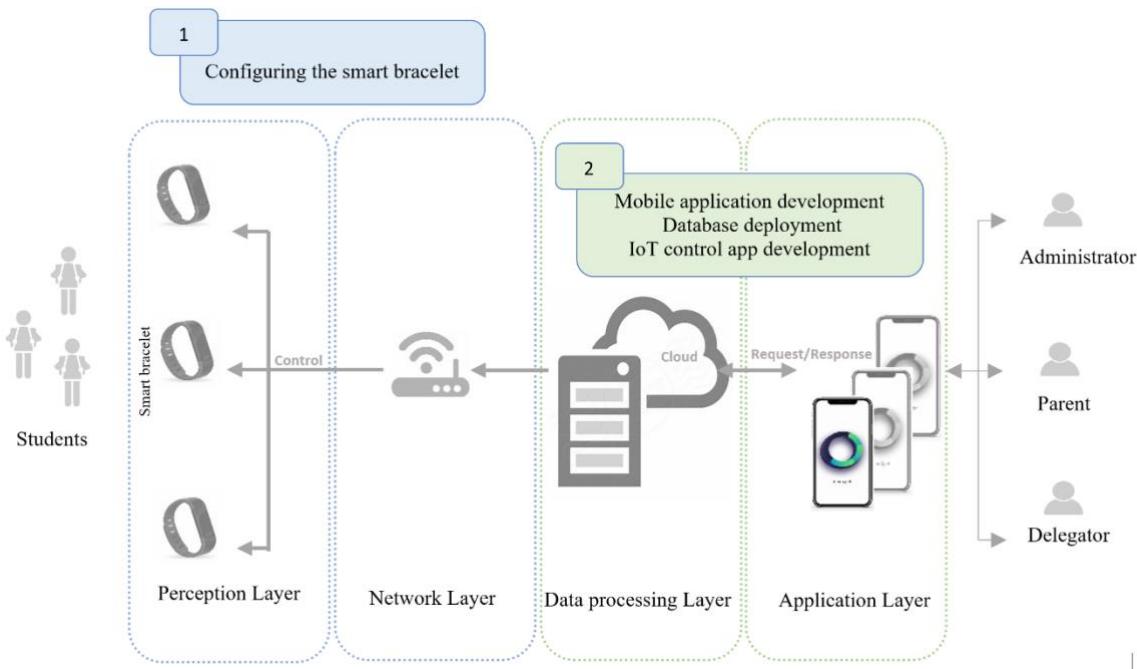


Figure 65 Architecture

4.7 Hardware implementation

4.7.1 Hardware implementation

There are different components used to build and configure the smart bracelet which includes: NodeMCU (ESP8266), RGB LED Strip, Lithium battery, and Jumper Wires as shown in Figure 66. These components are previously explained in the background chapter as shown in Table 6 IoT Configuration ,and it will be integrated together to create the smart bracelet. The main component of the bracelet is NodeMCU that is designed for IoT application. Table 37 shows the specifications of the NodeMCU.

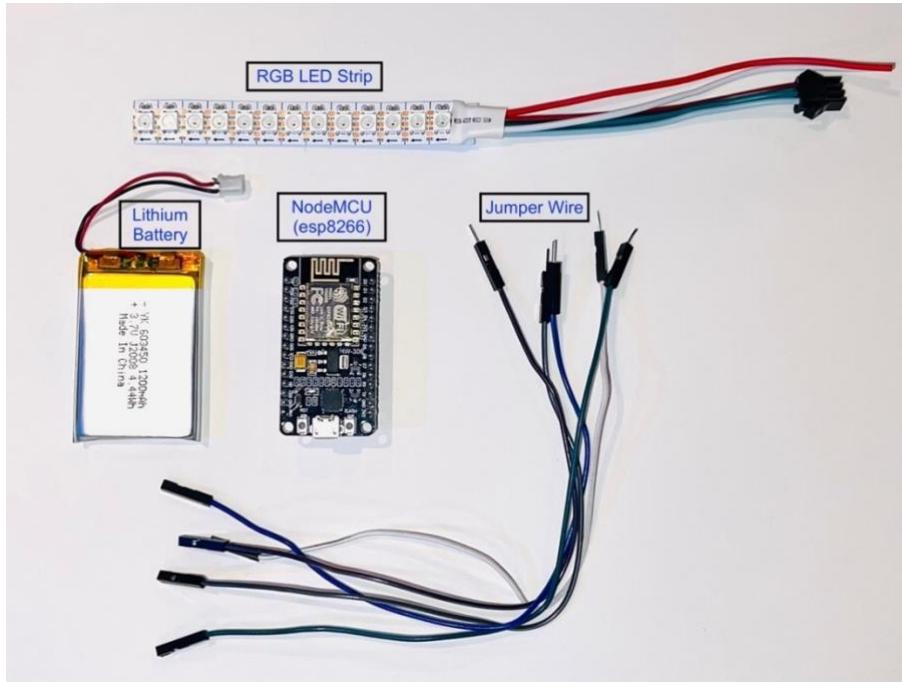


Figure 66 Hardware Component

Table 37 NodeMCU specifications

Component	Description
Power	NodeMCU can be powered through: Micro-USB, 3.3V, GND, Vin
Digital I/O Pins (DIO)	16
WiFi Built-In	802.11 b/g/n
Flash Memory/SRAM	4 MB / 64 KB
Analog In Pins	1

To know how to connect the hardware components together, the circuit diagram is designed as shown in Figure 67. Then, the hardware components are connected as follows: First, NodeMCU is connected to LED strip using three jumper wires in the following ways: for data transfer, power, and ground ports, they are each attached to D4, 3V3, and GND on the NodeMCU ports, respectively. Then, by using jumper wires, the Lithium Battery is connected to the NodeMCU through the 3V3 port for power and the GND port for a ground connection. Figure 68 shows the connected hardware components. Figure 69 shows the final bracelet prototype.

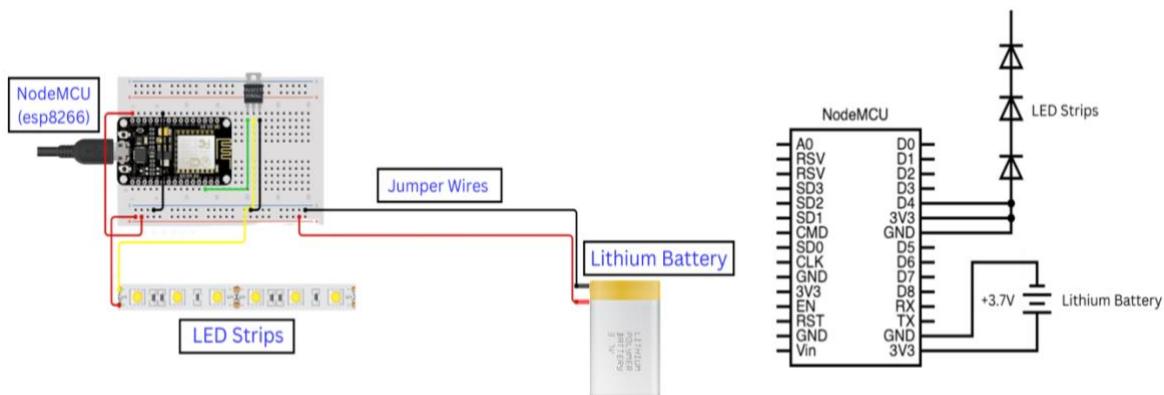


Figure 67 Circuit Diagram

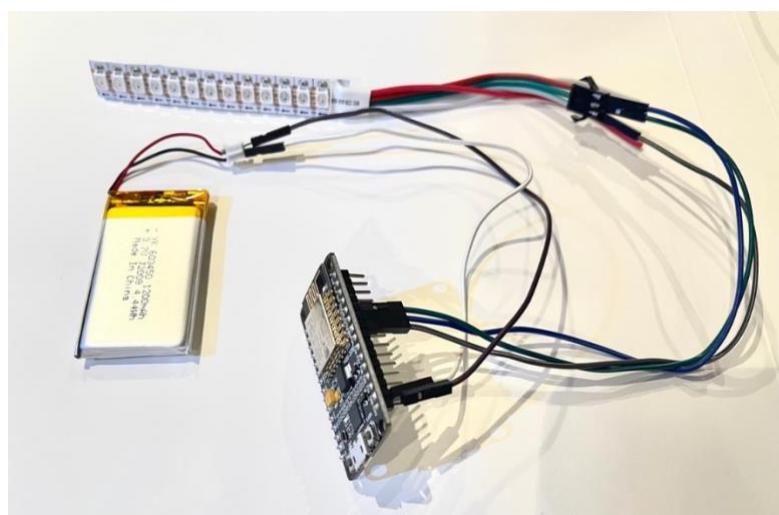


Figure 68 Integrated Hardware Components

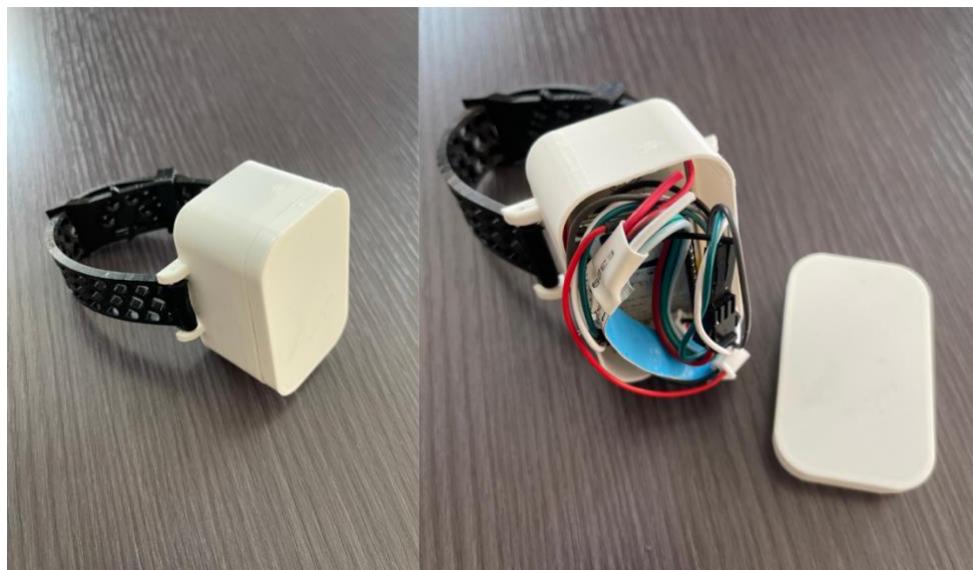


Figure 69 Bracelet Prototype

4.8 Software Components

4.8.1 Developing IoT control application

There are two protocols to connecting the hardware component to the server, the HTTP protocol and the MQTT protocol, and both protocols have been attempted. For HTTP protocols, the Arduino IDE and Visual Studio are used, while for MQTT protocols, Cumulocity IoT platform is utilized in addition to the Arduino IDE and Visual Studio. Cumulocity IoT is a platform developed by SoftwareAG, which provides connectivity and management of devices, the ability to analyze & leverage the data collected from IoT, and the ability to run IoT on-premises as well as in the cloud [37].

- HTTP Protocol

HTTP (Hyper Text Transfer Protocol) is use TCP while communicating. It is a request/reply protocol, data can be moved from servers to user devices quickly, easily, and in a stable manner using HTTP. A key component of HTTP is the guarantee that data transmitted from one device to another will not be corrupted. An HTTP communication protocol can be read by any device that supports HTTP [38].

- MQTT Protocol

MQTT (Message Queuing Telemetry Transport) runs over TCP / IP while communicating and transmitting data in a variety of formats using publish/subscribe instead of a client-server model. By using publish/subscribe system, the data sender (publisher) and data receiver (client) do not know each other because there is a broker between them, the broker is acting as a link between the client and the publisher. According to MQTT, it is a known topic that acts as a filter when a broker sends messages to everyone who has connected to it [38].

- Cumulocity Platform

Cumulocity platform was used as another way to implement a dashboard in addition to Arduino IDE and Visual Studio previously mentioned. The visual studio side sends an event when a parent clicks an arrive button that contains all parent information including (Parent name, Child name, Zone color, Arrive time, Arrive date), plus the device ID.

On the Cumulocity platform, there is a tenant for every user, where all connections and functions are stored, and each tenant is identified by a tenant ID. At the Arduino side, the device signified by Nodemcu is connected to Cumulocity via MQTT by using the tenant ID and the rest of tenant information as shown in Figure 70 and Figure 71.

```

#include <ESP8266WiFi.h>
#include <Ticker.h>
#include <AsyncMqttClient.h>
#define WIFI_SSID "PRO-4G"
#define WIFI_PASSWORD "050444**"
#define MQTT_HOST "https://iotccis21.cumulocity.com/apps/cockpit/index.html#/"
#define MQTT_PORT 1883
#define TENANT_ID "iotccis21"
#define TENANT_USER "439200788@student.ksu.edu.sa"
#define TENANT_PASSWORD "Renad11*#"
|
#define TOPIC "s/us"
#define DEVICE_ID "7050753"

AsyncMqttClient mqttClient;
Ticker mqttReconnectTimer;

WiFiEventHandler wifiConnectHandler;
WiFiEventHandler wifiDisconnectHandler;
Ticker wifiReconnectTimer;

```

Figure 70 Connecting To Cumulosity By MQTT

```

void createEvent(){
    mqttClient.publish(TOPIC,0,true,"400,c8y");
}

void setup() {
    //Starting Serialconnector
    Serial.begin(115200);
    Serial.println();
    Serial.println();

    wifiConnectHandler = WiFi.onStationModeGotIP(onWifiConnect);
    wifiDisconnectHandler = WiFi.onStationModeDisconnected(onWifiDisconnect);

    //MQTT
    mqttClient.onConnect(onMqttConnect);
    mqttClient.onDisconnect(onMqttDisconnect);
    mqttClient.setServer(MQTT_HOST, MQTT_PORT);
    mqttClient.setClientId(DEVICE_ID);
    mqttClient.setCredentials(TENANT_USER,TENANT_PASSWORD);

    //Connect to Wifi
    connectToWifi();
}

void loop() {
    sendWiFiStrenght(WiFi.RSSI());
    delay(2000);
}

```

Figure 71 Connecting To Cumulosity By MQTT

As a result, all parent information is displayed on the admin dashboard on the Cumulocity platform as shown in Figure 72.

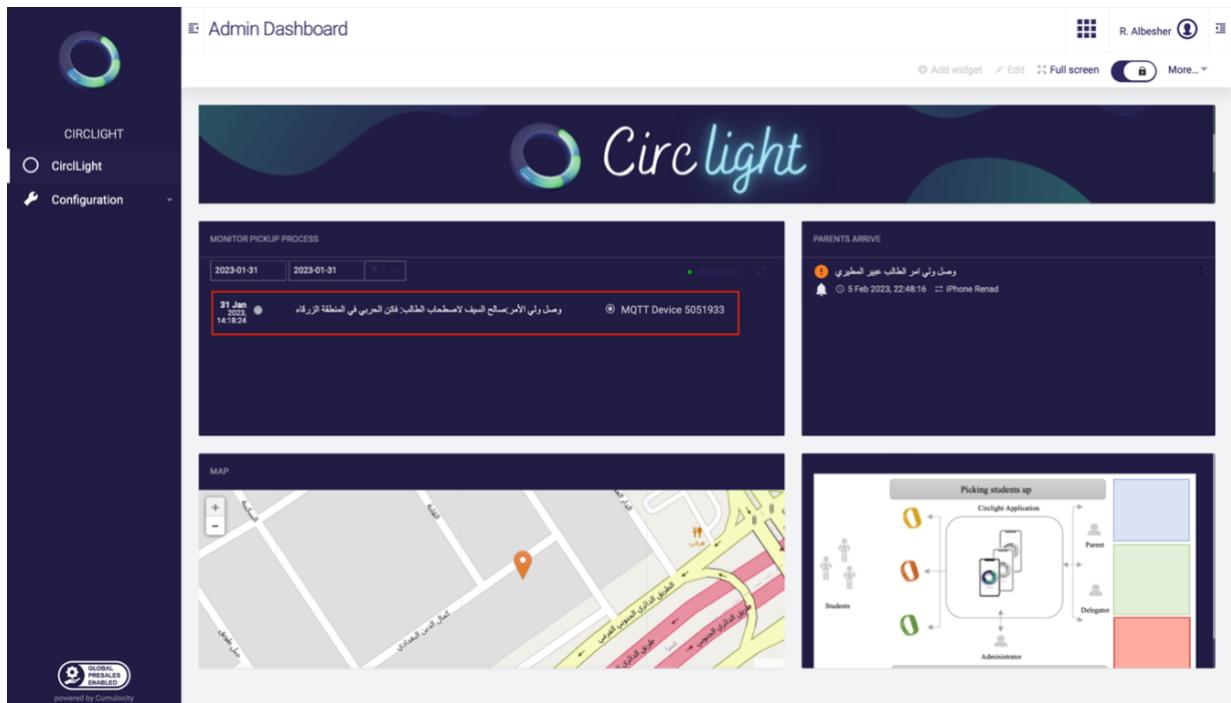


Figure 72 Admin Dashboard On Cumulocity

- Arduino IDE

Arduino IDE was used which is an open-source software that makes it easy to write code and upload it to the board. IDE stands for Integrated Development Environment, and it is compatible with a variety of operating systems, such as Windows and Mac OS. Moreover, it supports the C and C++ programming languages [39].

To implement the Pick-up function, Visual Studio and Arduino were used. As shown in Figure 73, on the side of Visual Studio when parent click a zone color the RGB color number to be illuminated is sent to Firebase along with the path and device ID for the data to be stored in the real-time database as shown in Figure 74.

```
//setpower
    setstatusofpower(bool value = false) {
        ref.child("/power").set(value ? 1 : 0);
    }

    setrbgcards(Color color) {
        for (int i = 0; i < selectedPersonList.length; i++) {

            String path = "/deviceData/" +
                selectedPersonList[i].deviceid.toString() +
                "/readings" +
                "/rgb";

            String value = color.red.toString() +
                "," +
                color.blue.toString() +
                "," +
                color.green.toString();
            ref.child(path).set(value);
        }
    }
}
```

Figure 73 Pick-up Function On Visual Studio

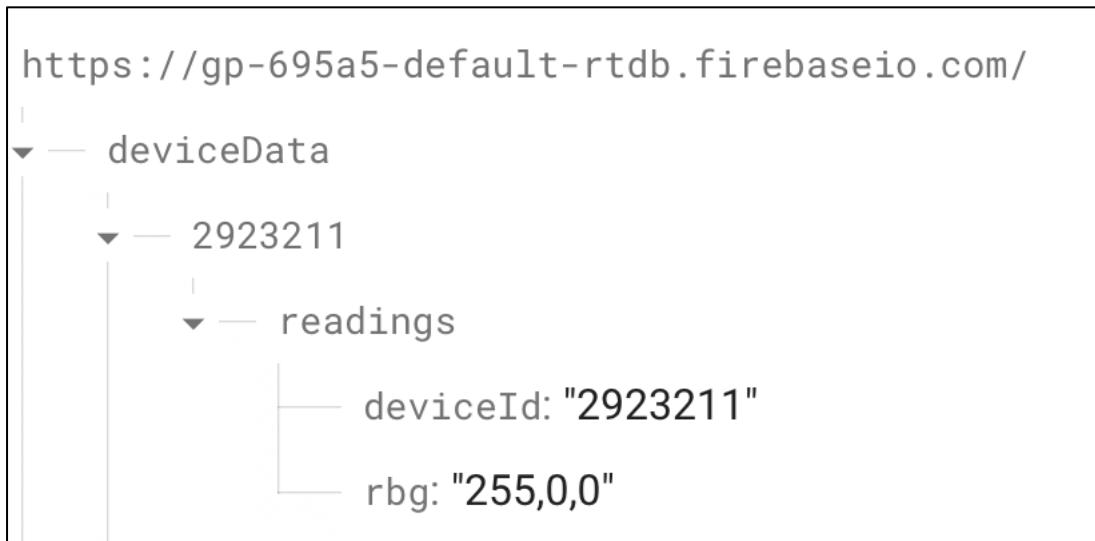


Figure 74 Realtime Database

The Arduino IDE then reads the path and the device ID which is the bracelet ID from the Realtime database to retrieve the color number as shown in Figure 75, and sends it to the NodeMCU to illuminate.

```
void loop()
{
    String rbgstatus = databasePath+"/rgb";
    String deviceidadd = databasePath+"/deviceId";

    Serial.println('inside');
    if (Firebase.ready())
    {

        if(isfirsttime){
            Firebase.setString(fbdo,deviceidadd,ESP.getChipId());
            Firebase.setString(fbdo,rbgstatus,"255,255,255");
            isfirsttime = false;
        }
    }
}
```

Figure 75 Pick-up Function On Arduino IDE

Accordingly, Figure 76 shows the led strip light matching the color of the zone clicked by the parent.

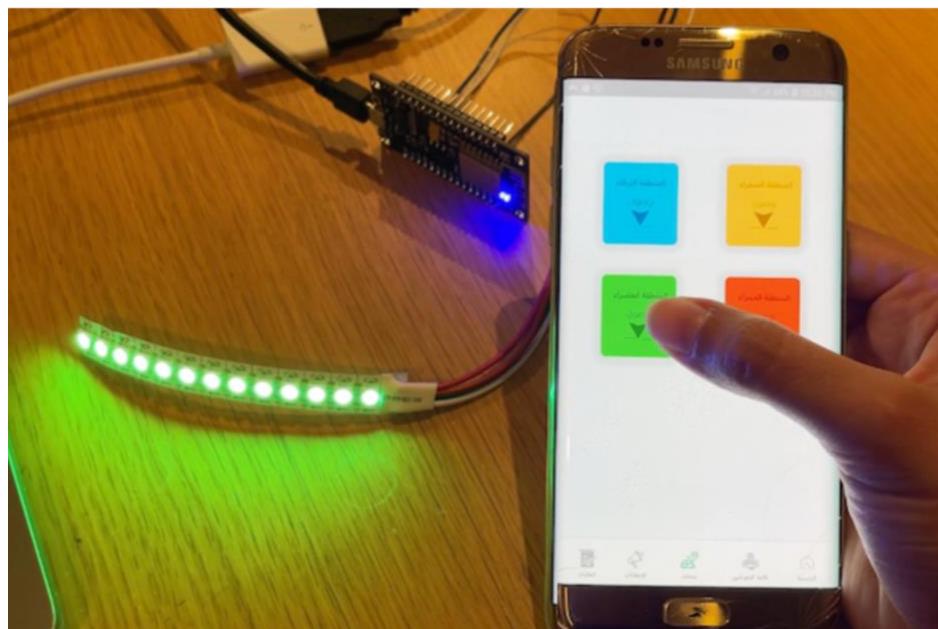


Figure 76 Lighting Result

4.8.2 Developing the mobile application

To deploy the Database of the application, Cloud Firestore is used [40] . The database is created according to the proposed data model. Additionally, a Realtime database is created as shown in Figure 74, as it is more efficient for controlling IoT devices.

Moreover, to develop the mobile application, we use Flutter which is an open-source UI software development kit created by Google, it is used to develop cross platform applications for Android, IOS, Linux, macOS, Windows, Google Fuchsia, and the web from a single codebase [41] . In addition, to implement the code and design of the application, we used Visual Studio Code (VS code) [42]. shows the major functions of the admin and the code-segments are presented in Appendix F.

Class (Student)

In this class the following functions are implemented which are:

- addStudent(DocId, Name, SUserName, SNationalID, SNationality, Class, SBloodType, AdminID)
- DeleteStudent(DocId)
- UpdateStudent(DocId, Field, Updated)
- Existstudent(DocId,ParentID,Name,SUserName,SNationalID,SNationality,Class,SBloodType, AdminID)

Class (Parent)

In this class the following functions are implemented which are:

- addParent(PN, PUserName, Email, PID, ParenPhoneNo, AltPhoneNum, Nationality, randompass, JobT, PRelativeRelation)
- DeleteParent(String DocId)
- UpdateParent (DocId, Field, Updated)

Class (Delegator)

In this class the following functions are implemented which are:

- UpdateDelegator(DocId, Field, Updated)

Class (Admin)

In this class the following functions are implemented which are:

- ParentListView()
- getAdminID()
- StudentListveiw()
- UpdateAdmin(DocId, Field, Updated)

Class (RequestDelgator)

In this class the following functions are implemented which are:

- AddRequest(DName, DUserName, IsAccepted, IsActive, SID, DACtive, Date, ParentID, DelegatorID)
- DeleteRequests(DocId)
- UpdateRequest(DocId, Field, Updated)

Class (Request)

In this class the following functions are implemented which are:

- AddRequestParent>Title, Status, Content, SID, Date, Res, Url, Type
- UpdateRequestParent(DocId, Field, Updated)
- DeleteRequestsParent(DocId)

Class (Dashboard)

In this class the following functions are implemented which are:

- PickupProcess (String name , Color color)
- ShowData (Date, PName, SName, Time, ZoneColor)

Class (Pickup)

In this class the following functions are implemented which are:

- Pickup (name , deviceid)

4.9 Implementation Difficulties

No	Problem	Solution
1	The connection between the esp32-S3 and the computer kept failing and no chip port could be identified.	Utilize the NodeMCU (esp8266) instead of the esp32-S3 because it has better support and a larger community. Additionally, NodeMCU has the same capability and with more resources.
2	Failed to launch the application on the simulation device in Virtual Studio Code.	It solved by update to the most recent version of the Android SDK and accept all licenses.
3	When using Virtual Studio Code a fetal error occurred in the application's firebase app.dart that prevents compilation	Using commands to clear flutter and include the dependencies for firebase core platform interface.
4	Kernel snaoshot.d fetal error prevented the Flutter framework in Virtual Studio Code from executing the application.	.pub cache file and pecspec.yaml were both changed
5	Experiencing difficulties with the edit pages detecting that the user has modified some fields to provide them the ability to ignore changes when returning to the previous page without storing the changes because it was two pages Edit Field and Edit page.	The two pages were combined and placed in a Method, where all the data required to detect that the user had edited some fields was stored and accessible.
6	When using Virtual Studio Code, firebase connection failed	Download firebase CLI and node.js

5 System Evaluation

The system is tested in this stage to verify that all components are functioning properly. The user acceptance testing is performed to see whether the system meets the user requirements and can be used by end users, the user acceptance testing include Demographics of Participants, Questionnaire and Interview Results and Discussion to obtain that the system evaluation is good or not.

5.1 Experimental Results

The experiment took place at King Saud University - Building 6, which was chosen to simulate the school area. The lighting bracelet was placed inside the building and measured at various distances from the application, and various scenarios were performed to test the functions.

Table 38 Experiment Test Cases

Test case	duration	Pass/Fail	Comments
A parent lights up a bracelet for one of his children.	0.69 sec	Pass	The application was tested with 30 users, and the average time recorded was 0.69 seconds.
A parent lights up a bracelet for all of his children.	0.81 sec	Pass	
Light bracelet for 2 different child, parent and zones.	0.91 sec	Pass	
Lights the bracelet at a distance of 20 meters.	0.73 sec	Pass	
Lights the bracelet when child on school yard	0.80 sec	Pass	
Lights the bracelet when child out of school yard.	0.88 sec	Pass	

5.1.1 Performance and Reliability

During the experiment, performance and reliability of the application were assessed. **Pressed color** refers to the color of the arrive button that is pressed by the parent or delegator and **Light Color** refers to the color of the light on the child's bracelet when the parent clicks the "arrive" button. **Start time** refers to the moment when the parent or delegator click arrive button, while **end time** is the moment when the child bracelet is light. The **duration** of the task is calculated by subtracting the start time from the end time. By analyzing these parameters, it was possible to determine the application's ability to execute tasks accurately and in a timely manner.

Table 39 Performance And Reliability

User	Pressed Color	Lighted Color	Start Time	End Time	Duration
User 1	Green	Green	10:15:14	3:15:14.66	0.66 sec
User 2	Green	Green	3:17:40	3:17:40.72	0.72 sec
User 3	Red	Red	3:20:20	3:20:20.59	0.59 sec
User 4	Yellow	Yellow	3:22:30	3:22:30.61	0.61 sec
User 5	Blue	Blue	3:24:30	3:24:30.77	0.77 sec
User 6	Green	Green	3:27:10	3:27:10.65	0.65 sec
User 7	Yellow	Yellow	3:29:00	3:29:00.59	0.59 sec
User 8	Blue	Blue	3:29:00	3:29:00.63	0.63 sec
User 9	Green	Green	3:29:00	3:29:00.70	0.70 sec
User 10	Red	Red	3:36:00	3:36:00.90	0.90 sec
User 11	Green	Green	3:39:00	3:36:01.02	1.02 sec
User 12	Blue	Blue	3:45:00	3:45:00.65	0.65 sec
User 13	Yellow	Yellow	3:50:00	3:50:00.60	0.60 sec
User 14	Green	Green	3:53:00	3:53:00.73	0.73 sec
User 15	Blue	Blue	7:40:00	7:40:00.69	0.69 sec
User 16	Yellow	Yellow	7:43:00	7:43:00.63	0.63 sec
User 17	Red	Red	7:46:00	7:46:00.81	0.81 sec
User 18	Blue	Blue	7:49:00	7:49:00.68	0.68 sec
User 19	Green	Green	7:52:00	7:52:00.64	0.64 sec
User 20	Blue	Blue	10:01:00	10:01:00.66	0.66 sec
User 21	Green	Green	10:04:00	10:04:00.63	0.63 sec
User 22	Yellow	Yellow	10:07:00	10:07:00.77	0.77 sec
User 23	Red	Red	10:10:00	10:10:00.61	0.61 sec
User 24	Blue	Blue	10:15:00	10:15:00.64	0.64 sec
User 25	Green	Green	10:17:00	10:17:00.74	0.74 sec
User 26	Blue	Blue	10:18:00	10:18:00.71	0.71 sec
User 27	Yellow	Yellow	10:20:00	10:20:00.60	0.60 sec
User 28	Blue	Blue	10:22:00	10:22:00.64	0.64 sec
User 29	Red	Red	10:24:00	10:24:00.83	0.83 sec
User 30	Green	Green	10:26:00	10:26:00.89	0.89 sec
Average Time			0.69 Second		
Accuracy			100%		

After testing the application on 30 users and collecting data, the performance histogram shows in Figure 77 represent the frequency of execution times for a pickup process. The highest recorded execution time was 1 minute and 2 seconds, while the lowest recorded execution time was 0.59 seconds. However, the histogram shows an average execution time of 0.69 seconds. A low average execution time indicates that the pickup process is performing well. The histogram likely shows most execution times around 0.69 seconds. The histogram suggests that the pickup process is efficient and effective, with consistent and reliable performance times.

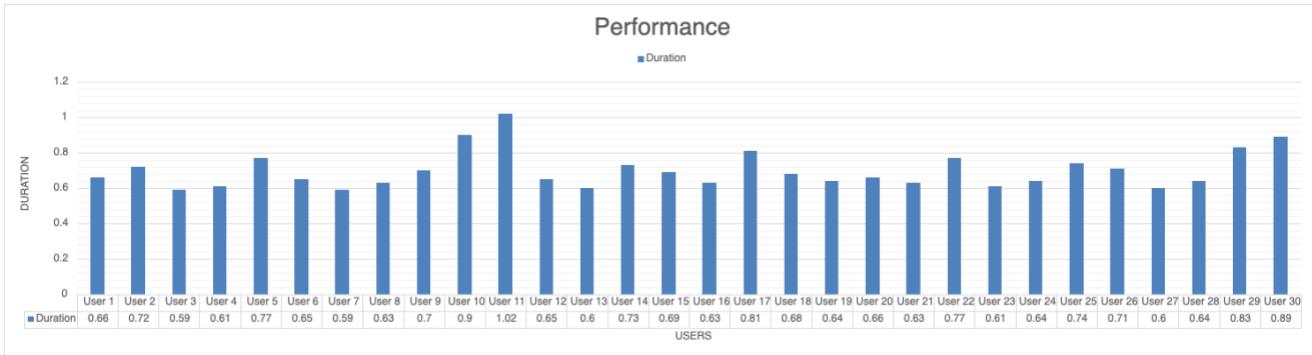


Figure 77 Performance Histogram

5.1.2 Efficiency

After conducting testing on an application with a sample of 30 users as shown in Figure 88 and collecting data on the average completion times for each task, an efficiency histogram was created to illustrate the distribution of completion times. As shown in the histogram in Figure 78, the values indicate varying levels of efficiency for different tasks within the application. And one of the tasks that stands out in terms of complexity is the assign student function. This process involves multiple steps and the completion of several forms with detailed information, resulting in a longer execution time compared to other tasks within the application. Despite the additional steps required, the assign student function still falls within an acceptable range of efficiency, with an average completion time of less than one minute [43]. Therefore, the assign student function is still able to operate efficiently within the application.

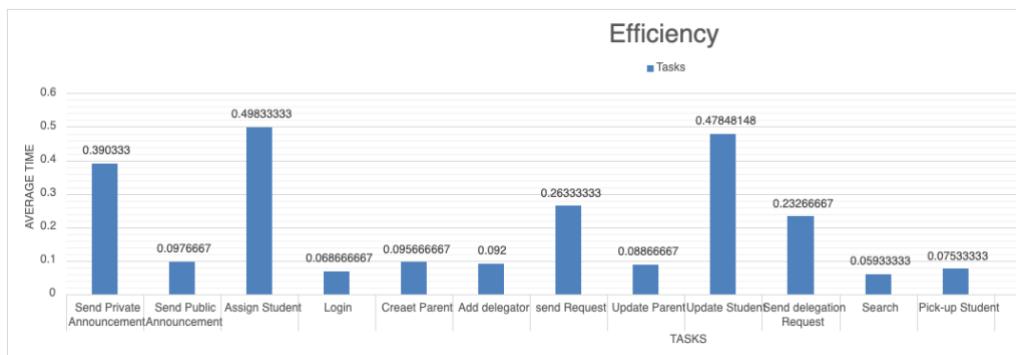


Figure 78 Efficiency Histogram

5.1.3 Effectiveness

After testing the application on 30 users as shown in Figure 89 and collecting data on the average errors made during each task, an effectiveness histogram created as shown in to represent the distribution of these errors. Each value on the histogram represents the average error for a specific task, and the histogram have a variety of values indicating different levels of effectiveness. As noticed the application overall maintains a low average error rate of less than 0.7 indicating that the application is operating at an acceptable level of effectiveness [35].

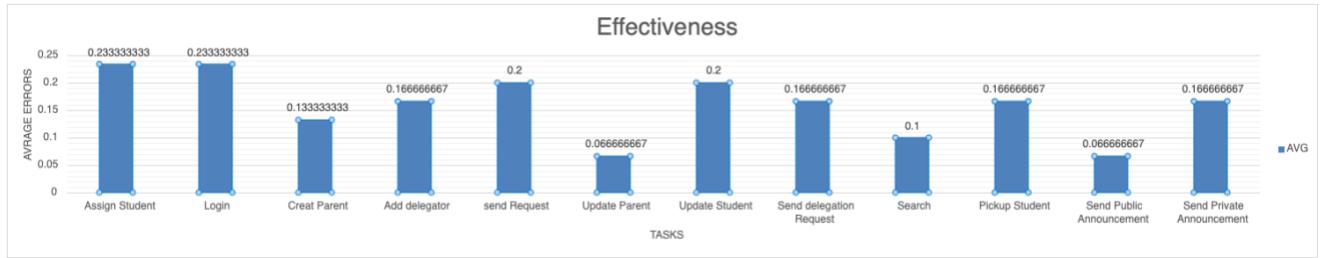


Figure 79 Effectiveness Histogram

5.1.4 Experiment Discussion

The range of effectiveness and efficiency demonstrated by the Circlight system is noteworthy, as it has been shown to perform well in different scenarios. The reliability of the system is evident in the consistent and correct lighting of the bracelet each time the parent presses the button to control it. Moreover, the system's security feature has been successfully implemented, allowing only authorized parents or delegated individuals to access the system and light up the child's bracelet.

The system's performance is also noteworthy, with the child's bracelet lighting up within an average of 0.69 seconds when the parent presses the pick-up button. This swift response time ensures that the pick-up process is efficient and easy for parents, reducing wait times and providing a seamless user experience.

5.2 User Acceptance Testing

User Acceptance Test (UAT) is a test that is conducted before the system is delivered to the end users. We will verify that the system meets the system requirements, as well as confirm its functionality and usability[44]. As a result, we conduct an acceptance test and invite users to test the application. The test scenario described below was used.

It was decided to simulate a working environment in which the user implements the functions using the application. As a result, the implementation was carried out using an Android mobile, an IOT lighting bracelet, and a user to test the functions. We have four types of users (Admin, Delegator,

Parent, and Student). The users will start the system and perform related tasks using the Circlight application such as adding a parent or student, implementing the pickup function and testing the lighting bracelet.

The experiment took place at King Saud University - Building 6 the place was chosen to simulate the school area where the lighting bracelet was inside the building and the user along with the Circlight application was outside the building where different scenarios were tested. Then, we give the user free control to try the system and after testing all system functionalities, a survey (shown in Appendix E: "Circlight" (استبانة تقييم تجربة المستخدم لتطبيق) is given to the user to fill it out and rate the system.

5.2.1 Demographics of Participants

The number of the users invited to test the system is 10 users. They were invited at different times so they can have their own experience. When it comes to the type of users, we have invited users from schools , parents and delegators to test the system. When it comes to the user's demographic, they were both female and male. As shown in Table 40 , the sample have different age, starting from 18 to 45 years old, but most of them were 26 to 35 years. When it comes to their technical background, most of the users have a medium and advanced background in technology.

Table 40 UAT Demographics of Participant

Demographics	Value	Number of participants
Age	18 - 25	2
	26 - 35	5
	36 - 45	3
	Over 45	0
Gender	Male	5
	Female	5
Technical background	High	4
	Medium	4
	Low	2

5.2.2 Questionnaire Results

After completing the test sessions, we chose to use the System Usability Scale (SUS)[35] , which is of the most used questionnaires to measure usability, and we show SUS Score Interpretation[45] and the way it works is the answers are given points ranging between 1-5, where strongly disagree is given 1, and strongly agree is given 5. And the testing Questionnaires' Result are given in Table 42. The system was tested by 30 users , each user had a questionnaire to provide feedback on the system, as illustrated in Appendix E: "Circlight" ، استبانة تقييم تجربة المستخدم لتطبيق as shown in Table 42 below it was reported that 25 out of 30 said that it was a great experience to try the Circlight system . Also, 27 out of 30 said that they would frequently use the Circlight application in their daily lives, which means that they find that Circlight is a useful application. Also, about the complexity of the application, more than half of candidates said that the application is not complex and is easy to use and understandable. Most of the candidates (6 out of 10) say that they will not need technical support to use the functions in the Circlight application, and many people will learn and understand how to use the application very quickly. All of the candidates agreed that the functions in the application were well integrated and not conflicting or inconsistent. Also, all of the candidates said that the application was not awkward, and they felt very confident when they used it. We also asked them if they face any difficulties with some functions in the application and what those functions are, as shown in Table 42 all of them agreed that everything is clear, and they do not face any difficulties while using the application.

Table 41 SUS Score Interpretation [44]

SUS Score	Grade	Adjective Rating
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

Table 42 Questionnaire Results

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1 . I think that I would like to use this system frequently.	0	0	3	5	22
2 . I found the system unnecessarily complex.	19	9	2	0	0
3 . I thought the system was easy to use.		0	5	0	25
4 . I think that I would need the support of a technical person to be able to use this system.	30	0	0	0	0
5 . I found the various functions in this system were well integrated.	0	0	0	2	28
6 . I thought there was too much inconsistency in this system.	26	4	0	0	0
7 . I would imagine that most people would learn to use this system very quickly.	0	0	5	11	14
8 . I found the system very cumbersome to use.	22	5	3	0	0
9 . I felt very confident using the system	0	0	0	3	27
10 . I needed to learn a lot of things before I could get going with this system	30	0	0	0	0

Table 43 Participant's SUS Score

Response No.	SUS Score	Grade	Adjective rating
1	90	A	Excellent
2	87.5	A	Excellent
3	92.5	A	Excellent
4	97.5	A	Excellent
5	97.5	A	Excellent
6	97.5	A	Excellent
7	100	A	Excellent
8	97.5	A	Excellent
9	87.5	A	Excellent
10	97.5	A	Excellent
11	100	A	Excellent
12	87.5	A	Excellent
13	100	A	Excellent
14	100	A	Excellent
15	100	A	Excellent
16	97.5	A	Excellent
17	97.5	A	Excellent
18	92.5	A	Excellent
19	97.5	A	Excellent
20	92.5	A	Excellent
21	92.5	A	Excellent

22	100	A	Excellent
23	97.5	A	Excellent
24	95	A	Excellent
25	100	A	Excellent
26	97.5	A	Excellent
27	100	A	Excellent
28	97.5	A	Excellent
29	100	A	Excellent
30	97.5	A	Excellent

5.3 Quality Attributes (NFR testing)

Table 44 Quality Attributes (NFR testing)

User Story	Quality Attribute	Mesure	Result
As a Parent I want to be able to see bracelet to light up for no more than 6 seconds from pressing the arrive button [33].	Performance: How fast a system can respond to user's action?	Compute the time the bracelet responds to the user click. The bracelet should lights from the user click with less than 6 seconds.	<p>The Circlight user click arrive, then bracelet light up to responds to user click.</p> <p>As a result of testing the application with 30 users, the time for the bracelet to light up from the point at which the user clicks are calculates as shown in Table 39 and the minimum time was 0.59 second and the maximum time was 1.02 second where the average was 0.69 second which is calculated as follows:</p> <ol style="list-style-type: none"> 1. The sum of the duration for each click / the number of users 2. $20.99 / 30 = 0.69$ sec

As a user I want to be identified and authenticated so that no one can access my account and get the privileges that assigned to the account.	Security: It represents how identify and authenticate the users and let them gain access to their accounts	The system should identify and authenticate the users based on their email and password, then let them gain the access based on their role.	Circlight system was tested by 30 users to test the security of the system shown in Appendix I, and yes, the users gain the access only if they enter the correct email and password otherwise, they will not gain the access to their accounts.
As a user I want the Circlight application to be available 10 hours so that I can use it most of the time.	Availability: is the probability that a system is available to functioning properly at a given time.	Compute if Circlight system is available 10 hours a day.	Circlight system was tested by four users while working on the project and yes, the system was available for 10 hours a day for the past 3 months.
As a user I want the bracelet to light up on correct time with correct color so that I can pick-up the child easily.	Reliability: How accurate and reliable is the system and how well does it perform as expected?	Compute the time the bracelet responds to the user click. The bracelet should lights from the user click with less than 6 seconds. And calculate the accuracy of the color user clicked and the color of the bracelet light up.	The Circlight user click arrive, then bracelet light up to responds to user click. As a result of testing the application with 30 users as shown in Table 39, the average time for the bracelet to light up from the point at which the user clicks is 0.69 seconds which is calculated as follows: 1. The sum of the duration for each click / the number of users 2. $20.99 / 30 = 0.69$ sec

			<p>In addition, the accuracy was 100%, which is calculated as follows:</p> $\frac{\text{True positive} + \text{True negative}}{\text{True positive} + \text{True negative} + \text{False positive} + \text{False negative}} * 100$ $= 100\%$
As a user, I want to use the application in easy and simple way so that I got satisfied and keep using the application	<p>Usability</p> <p>1. Satisfaction:</p> <p>It is the degree of comfort and acceptability of the system for the user</p>	<p>To measure the Satisfaction of the system we used the System Usability Scale (SUS) which is one of 10 Benchmarks for User Experience Metrics</p>	<p>A System Usability Scale (SUS) containing 10 questions have been used shown in Table 42. After distributing the questionnaire to the testing users, we calculated the average of the System Usability Scale (SUS), and we got a 96.25 average score where the minimum score was 87.5 and the maximum score was 100 as shown in Appendix J. According to the 10 benchmarks for user experience metrics, the usability of the Circlight system is above the average and very good since the average System Usability Scale (SUS) score is 68 .</p>

<p>As a user, I want to be able to complete tasks in a short amount of time in less than 1 minute so that I can manage pick-up process efficiently [43]</p>	<p>Usability</p> <p>2. Efficiency: It represents how quickly the user can perform tasks</p>	<p>Compute the time it takes for a user to perform the task in the system</p>	<p>The following equation was used to calculate the time of each task executed by the user as shown in Appendix K:</p> $\text{Task Time} = \text{End Time} - \text{Start Time}$ <p>Based on the time-based efficiency, we calculated Circlight's efficiency:</p> <p>Average task time = 18.0 sec</p> <p>Minimum task time = 4.01 sec</p> <p>Maximum task time = 52 sec</p>
<p>As a user, I want to be able to complete tasks with an average number of errors 0.7 per task so that I can do what I need effective [35].</p>	<p>Usability</p> <p>3. Effectiveness: How clear and simple to implement the processes within the system is?</p>	<p>To measure the Effectiveness of the system we use the Average number of errors which is one of 10 Benchmarks for User Experience Metrics [46]</p>	<p>A form contains all the functions in the system, then each user depends in his/her role try these functions, then calculate the number of the errors made by users without repeating the same functions as shown in Appendix L. Then calculated the average number of errors per task.</p> <p>Average number of errors of all tasks = 0.16 error/task</p> <p>Where the minimum number of errors of all tasks = 0 error/task</p> <p>And the maximum = 0.50 error/task.</p>

6 Conclusions and Future Work

6.2 Global and local impact

One of the main goals of the Circlight application is to serve local and possibly global communities by assisting schools and parents who struggle with communicating with schools and picking-up processes to overcome the problems they encounter daily.

6.2.1 Global impact

Circlight can impact people across the world and in all communities because there are people in every community that have communication issues with school and pick-up problems. By utilizing current technology, it will assist them and make their lives easier. Circlight's key goals are to improve communication between parents and schools and to make the pick-up procedure easier.

6.2.2 Local impact

Circlight enables the bracelet to simply receive and respond to all commands from users acting on their behalf. This is especially beneficial for local communities experiencing communication and pick-up issues. Circlight was developed with modern and smart components that everyone can utilize. Circlight can be used to inform schools and parents of significant things. It can also be used to notify the student and shift teacher of the presence of a parent. This will increase the involvement of schools and parents and have a greater impact on them.

6.3 Problems and challenges encountered during the software development

This section will show challenges that the team face during development of application from documentation, coding and deployment. Adding to Implementation Difficulties the following challenges:

1. Determining the correct technology inside the bracelets to light it up.
2. Bluetooth limitation that can impedes the communication between the bracelet and the application.
3. Trouble determining the right hardware piece for the bracelet.
4. Trouble reaching IOT experts to get consultants.

6.4 Limitations of the system

1. Circlight does not support English language.
2. Circlight does not provide ability for teachers to communicate with parents.
3. Check the parent's availability before sending notification for students.
4. Use extra security measure in delegating feature.

6.5 The main contribution of the project

The Circlight system can provide great value to people who struggle with school communication and pick-up processes by providing IoT Wearable bracelet. Circlight can assist by engaging them in communication with schools and facilitating pick-up. It will also allow schools to easily distribute important events to parents. The Circlight system will aid in engaging the Saudi community in this fashion.

6.6 Future work

The current system proposed is still limited in some aspects, and further development will be adopted in the future. In particular, limitations that need to be improved are as following:

1. Improve the application to be a platform.
2. Support English language.
3. Before sending notification to students, check the parent's availability in the area around the school.
4. Use QR code scanner embedded in the application to improve the delegation process and security.

7 Acknowledgements

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9 Appendix

9.2 Appendix A: Admin interview

- 1- ما هي الاجراءات المتبعة حاليا في اصطحاب الطلبة؟ هل يتم السماح لجميع الأطفال بمغادرة المدرسة؟
- 2- هل ميكروفون المدرسة يغطي كل منطقة المدرسة أم الفناء الخارجي فقط؟
- 3- هل تعتقد أن الطلاب يغادرون المدرسة فقط عندما يتم استدعائهم في الميكروفونات؟
- 4- ما هي القواعد المتبعة حاليا لضمان سلامة الطالب في ترك المدرسة؟
- 5- ما هو الإجراء الذي يتبعه المعلم المناوب عندما يتاخرولي أمر الطالب؟
- 6- هل المنطقة الخارجية للمدرسة منظمة (موقف سيارات ، المداخل ، المخارج)؟
- 7- هل واجهت اي مشاكل خارج حدود المدرسة؟
- 8- هل تعتقد أن وجود تطبيق يسمح للاباء بأخبار أبنائهم بوجودهم سبقل من وقت انتظار المعلم المناوب ويقلل من الازدحام؟
- 9- هل تعتقد أن التنظيم خارج المدارس إلى مناطق قد يساهم في تنظيم أولياء الأمور خارج المدارس؟
- 10- كم عدد المناطق خارج منطقة المدرسة التي تقضلها؟
- 11- ما هو نوع التواصل المطلوب بين أولياء الأمور وإدارة المدرسة ومديريها؟
- 12- هل تعاني عادة من التأخر في الحصول على موافقة الوالدين على اوراق مهمة مثل اخذ لفاح معين ولماذا؟
- 13- كيف تتوصل حالياً مع أولياء الأمور عندما تريد إبلاغهم بأي تحديث مثل (تغيير وقت الخروج,...)؟
- 14- هل تجد صعوبة في التواصل مع والد الطفل لاطلاعهم على أي تغييرات؟
- 15- ما هي أهم الميزات التي تود أن تراها في التطبيق؟

9.3 Appendix B: delegator interview

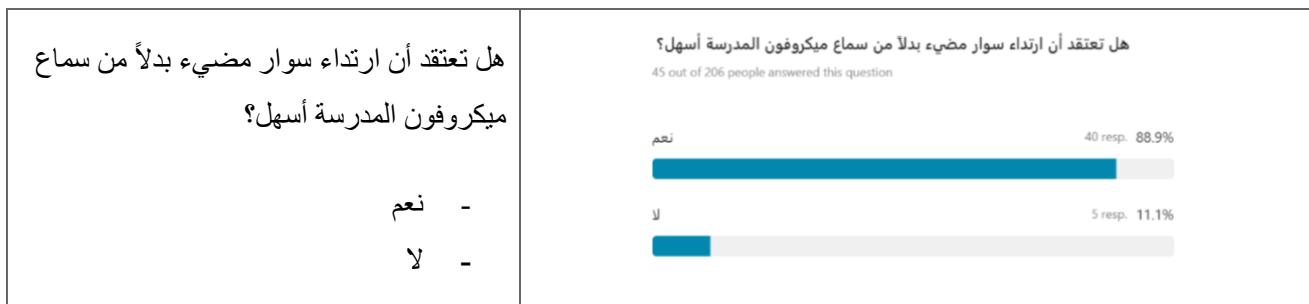
- 1- كم من الوقت يستغرق عادة لاصطحاب جميع الأطفال من المدرسة؟
- 2- الى اي مدى أنت راضٍ عن عملية الاستلام الحالية؟
- 3- هل وصل اي طالب متاخراً لأنه لم يتمكن من سماع الميكروفون؟
- 4- ما هو الإجراء الحالي لتسجيل حافلات الأطفال؟
- 5- هل تعتقد أن وجود تطبيق يسمح لك بإعلام الطلاب بحضورك سبقل من وقت الانتظار؟
- 6- ما هي أهم الميزات التي تود أن تراها في التطبيق؟

9.4 Appendix C: Student Questionnaire

Cirelight هو تطبيق للهاتف المحمول مصمم لتسهيل التواصل مع المدرسة وإدارة عملية اصطحاب الطلاب وذلك باستخدام سوار ذكي متصل بالتطبيق. يهدف التطبيق أيضًا إلى سد الفجوة بين موظفي إدارة المدرسة والمدير وأولياء أمور الطلاب.

Table 45 Student Questionnaire

Questions	Answers																		
<p>كيف تصف نفسك؟</p> <p>- ولی أمر - طالب</p>	<p>كيف تصف نفسك؟ 206 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> <th>Responses</th> </tr> </thead> <tbody> <tr> <td>ولي أمر</td> <td>78.2%</td> <td>161 resp.</td> </tr> <tr> <td>طالب</td> <td>21.8%</td> <td>45 resp.</td> </tr> </tbody> </table>	Category	Percentage	Responses	ولي أمر	78.2%	161 resp.	طالب	21.8%	45 resp.									
Category	Percentage	Responses																	
ولي أمر	78.2%	161 resp.																	
طالب	21.8%	45 resp.																	
<p>نود الحصول على موافقة الوالدين على ما يلي قبل البدء بالاستبيان:</p> <p>- أقبل طرح الأسئلة على طفلي وأوافق على استخدام هذه المعلومات في الدراسات والأبحاث</p>	<p>نود الحصول على موافقة الوالدين على ما يلي قبل البدء بالاستبيان: 45 out of 206 people answered this question (with multiple choice)</p> <p>أقبل طرح الأسئلة على طفلي وأوافق على استخدام هذه المعلومات في الدراسات والأبحاث 45 resp. 100%</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> <th>Responses</th> </tr> </thead> <tbody> <tr> <td>Accepted</td> <td>100%</td> <td>45 resp.</td> </tr> </tbody> </table>	Category	Percentage	Responses	Accepted	100%	45 resp.												
Category	Percentage	Responses																	
Accepted	100%	45 resp.																	
<p>إلى أي مدى أنت راضٍ عن العملية الحالية لاصطحاب والديك من المدرسة؟</p> <p>لاصطحاب والديك لك من المدرسة؟</p> <p>1 (غير راضٍ ابداً) 2 (غير راضٍ) 3 (محايد) 4 (راضٍ) 5 (راضٍ جداً)</p>	<p>إلى أي مدى أنت راضٍ عن العملية الحالية لاصطحاب والديك من المدرسة? 45 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> <th>Responses</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>6.7%</td> <td>3 resp.</td> </tr> <tr> <td>2</td> <td>8.9%</td> <td>4 resp.</td> </tr> <tr> <td>3</td> <td>35.6%</td> <td>16 resp.</td> </tr> <tr> <td>4</td> <td>15.6%</td> <td>7 resp.</td> </tr> <tr> <td>5</td> <td>33.3%</td> <td>15 resp.</td> </tr> </tbody> </table>	Category	Percentage	Responses	1	6.7%	3 resp.	2	8.9%	4 resp.	3	35.6%	16 resp.	4	15.6%	7 resp.	5	33.3%	15 resp.
Category	Percentage	Responses																	
1	6.7%	3 resp.																	
2	8.9%	4 resp.																	
3	35.6%	16 resp.																	
4	15.6%	7 resp.																	
5	33.3%	15 resp.																	
<p>إلى أي مدى تجد صعوبة في العثور على والديك خارج المدرسة؟</p> <p>خارج المدرسة؟</p> <p>1 (سهل جداً) 2 (سهل) 3 (محايد) 4 (صعب) 5 (صعب جداً)</p>	<p>إلى أي مدى تجد صعوبة في العثور على والديك خارج المدرسة? 45 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> <th>Responses</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>13.3%</td> <td>6 resp.</td> </tr> <tr> <td>2</td> <td>15.6%</td> <td>7 resp.</td> </tr> <tr> <td>3</td> <td>33.3%</td> <td>15 resp.</td> </tr> <tr> <td>4</td> <td>17.8%</td> <td>8 resp.</td> </tr> <tr> <td>5</td> <td>20%</td> <td>9 resp.</td> </tr> </tbody> </table>	Category	Percentage	Responses	1	13.3%	6 resp.	2	15.6%	7 resp.	3	33.3%	15 resp.	4	17.8%	8 resp.	5	20%	9 resp.
Category	Percentage	Responses																	
1	13.3%	6 resp.																	
2	15.6%	7 resp.																	
3	33.3%	15 resp.																	
4	17.8%	8 resp.																	
5	20%	9 resp.																	

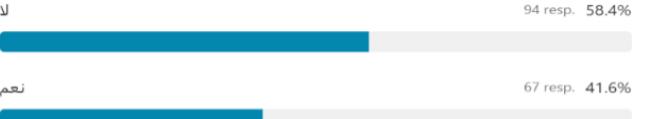


9.5 Appendix D: Parents Questionnaire

Cirelight هو تطبيق للهاتف المحمول مصمم لتسهيل التواصل مع المدرسة وإدارة عملية اصطحاب الطلاب وذلك باستخدام سوار ذكي متصل بالتطبيق. يهدف التطبيق أيضاً إلى سد الفجوة بين موظفي إدارة المدرسة والمدير وأولياء أمور الطلاب.

Table 46 Parents Questionnaire

Question	Answer												
مدارس أطفالك (حدد جميعها اذا انطبقت):	<p>مدارس أطفالك (حدد جميعها اذا انطبقت):</p> <p>161 out of 206 people answered this question (with multiple choice)</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>ابتدائي</td> <td>71.4%</td> </tr> <tr> <td>ثانوي</td> <td>45.3%</td> </tr> <tr> <td>متوسط</td> <td>45.3%</td> </tr> </tbody> </table>	Category	Percentage	ابتدائي	71.4%	ثانوي	45.3%	متوسط	45.3%				
Category	Percentage												
ابتدائي	71.4%												
ثانوي	45.3%												
متوسط	45.3%												
ما هي المدة التي تستغرقها عادة لاصطحاب أطفالك من المدرسة؟ وهذا يشمل الخروج (من محيط المدرسة)	<p>ما هي المدة التي تستغرقها عادة لاصطحاب أطفالك من المدرسة؟ (وهذا يشمل الخروج من محيط المدرسة)</p> <p>161 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>أقل من نصف ساعة</td> <td>55.9%</td> </tr> <tr> <td>من نصف ساعة الى ساعة</td> <td>36.6%</td> </tr> <tr> <td>أكثر من ساعة</td> <td>7.5%</td> </tr> </tbody> </table>	Category	Percentage	أقل من نصف ساعة	55.9%	من نصف ساعة الى ساعة	36.6%	أكثر من ساعة	7.5%				
Category	Percentage												
أقل من نصف ساعة	55.9%												
من نصف ساعة الى ساعة	36.6%												
أكثر من ساعة	7.5%												
إلى أي مدى أنت راضٍ عن عملية الاستلام الحالية؟	<p>إلى أي مدى أنت راضٍ عن عملية الاستلام الحالية؟</p> <p>161 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>1 (غير راضٍ ابداً)</td> <td>13.7%</td> </tr> <tr> <td>2 (غير راضٍ)</td> <td>19.9%</td> </tr> <tr> <td>3 (محايد)</td> <td>31.7%</td> </tr> <tr> <td>4 (راضٍ)</td> <td>16.1%</td> </tr> <tr> <td>5 (راضٍ ابداً)</td> <td>18.6%</td> </tr> </tbody> </table>	Category	Percentage	1 (غير راضٍ ابداً)	13.7%	2 (غير راضٍ)	19.9%	3 (محايد)	31.7%	4 (راضٍ)	16.1%	5 (راضٍ ابداً)	18.6%
Category	Percentage												
1 (غير راضٍ ابداً)	13.7%												
2 (غير راضٍ)	19.9%												
3 (محايد)	31.7%												
4 (راضٍ)	16.1%												
5 (راضٍ ابداً)	18.6%												

<p style="text-align: center;">4 (راضي) - 5 (راضي جداً) -</p>																			
<p>هل تعتقد أنه من الخطورة على الأطفال انتظار والديهم خارج المدرسة؟</p> <p style="text-align: center;">- نعم - - لا -</p>	<p>هل تعتقد أنه من الخطورة على الأطفال انتظار والديهم خارج المدرسة؟ 161 out of 206 people answered this question</p>  <table border="1"> <thead> <tr> <th>الإجابة</th> <th>النسبة (%)</th> <th>الرеспونس (الردود)</th> </tr> </thead> <tbody> <tr> <td>نعم</td> <td>97.5%</td> <td>157 resp.</td> </tr> <tr> <td>لا</td> <td>2.5%</td> <td>4 resp.</td> </tr> </tbody> </table>	الإجابة	النسبة (%)	الرеспونس (الردود)	نعم	97.5%	157 resp.	لا	2.5%	4 resp.									
الإجابة	النسبة (%)	الرеспونس (الردود)																	
نعم	97.5%	157 resp.																	
لا	2.5%	4 resp.																	
<p>هل تعتقد أن مناداة أطفالك باستخدام ميكروفون المدرسة هو أفضل طريقة لإبلاغهم بوصولك؟</p> <p style="text-align: center;">- نعم - - لا -</p>	<p>هل تعتقد أن مناداة أطفالك باستخدام ميكروفون المدرسة هو أفضل طريقة لإبلاغهم بوصولك؟ 161 out of 206 people answered this question</p>  <table border="1"> <thead> <tr> <th>الإجابة</th> <th>النسبة (%)</th> <th>الرеспونس (الردود)</th> </tr> </thead> <tbody> <tr> <td>لا</td> <td>58.4%</td> <td>94 resp.</td> </tr> <tr> <td>نعم</td> <td>41.6%</td> <td>67 resp.</td> </tr> </tbody> </table>	الإجابة	النسبة (%)	الرеспونس (الردود)	لا	58.4%	94 resp.	نعم	41.6%	67 resp.									
الإجابة	النسبة (%)	الرеспونس (الردود)																	
لا	58.4%	94 resp.																	
نعم	41.6%	67 resp.																	
<p>ما هي أكثر المشكلات شيوعاً التي تواجهها عند إخراج طفلك من المدرسة؟ (حدد كل ما ينطبق)</p> <ul style="list-style-type: none"> - البحث عن موقف للسيارات - استدعاء الأطفال باستخدام الميكروفون، مثل: عدم وضوح الصوت - الاصطفاف في منطقة الميكروفون - مغادرة منطقة المدرسة بعد اصطحاب أطفالي - العثور على أطفالي بعد مناداتهم 	<p>هي أكثر المشكلات شيوعاً التي تواجهها عند إخراج طفلك من المدرسة؟ (حدد كل ما ينطبق) 161 out of 206 people answered this question (with multiple choice)</p>  <table border="1"> <thead> <tr> <th>المشكلة</th> <th>النسبة (%)</th> <th>الرеспونس (الردود)</th> </tr> </thead> <tbody> <tr> <td>البحث عن موقف للسيارات</td> <td>81.4%</td> <td>131 resp.</td> </tr> <tr> <td>استدعاء الأطفال باستخدام الميكروفون، مثل: عدم وضوح الصوت</td> <td>62.7%</td> <td>101 resp.</td> </tr> <tr> <td>الاصطفاف في منطقة الميكروفون</td> <td>59.6%</td> <td>96 resp.</td> </tr> <tr> <td>مغادرة منطقة المدرسة بعد اصطحاب أطفالي</td> <td>57.8%</td> <td>93 resp.</td> </tr> <tr> <td>العثور على أطفالي بعد مناداتهم</td> <td>42.9%</td> <td>69 resp.</td> </tr> </tbody> </table>	المشكلة	النسبة (%)	الرеспونس (الردود)	البحث عن موقف للسيارات	81.4%	131 resp.	استدعاء الأطفال باستخدام الميكروفون، مثل: عدم وضوح الصوت	62.7%	101 resp.	الاصطفاف في منطقة الميكروفون	59.6%	96 resp.	مغادرة منطقة المدرسة بعد اصطحاب أطفالي	57.8%	93 resp.	العثور على أطفالي بعد مناداتهم	42.9%	69 resp.
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<p>إلى أي مدى تعتقد أن تنظيم المحيط الخارجي للمدرسة إلى مناطق ملونة قد يساهم في تنظيم الحركة المرورية ويساعد في وصول الطفل لوالديه بسلامة؟ (انظر الصورة التالية التي توضح العملية)</p> <p>1 (غير راضي أبداً) -</p> <p>2 (غير راضي) -</p> <p>3 (محايد) -</p> <p>4 (راضي) -</p> <p>5 (راضي جداً) -</p>	<p>إلى أي مدى تعتقد أن تنظيم المحيط الخارجي للمدرسة إلى مناطق ملونة قد يساهم في تنظيم الحركة المرورية ويساعد في وصول الطفل لوالديه بسلامة؟ (انظر الصورة التالية التي توضح العملية)</p> <p>161 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>النوع</th> <th>النسبة (%)</th> <th>العدد</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>14.3%</td> <td>23 resp.</td> </tr> <tr> <td>2</td> <td>6.8%</td> <td>11 resp.</td> </tr> <tr> <td>3</td> <td>29.2%</td> <td>47 resp.</td> </tr> <tr> <td>4</td> <td>18%</td> <td>29 resp.</td> </tr> <tr> <td>5</td> <td>31.7%</td> <td>51 resp.</td> </tr> </tbody> </table>	النوع	النسبة (%)	العدد	1	14.3%	23 resp.	2	6.8%	11 resp.	3	29.2%	47 resp.	4	18%	29 resp.	5	31.7%	51 resp.
النوع	النسبة (%)	العدد																	
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4	18%	29 resp.																	
5	31.7%	51 resp.																	
<p>كيف تخبر موظفي الإدارة بأنك من الممكن أن تتأخر في اصطحاب أطفالك (حدد جميع الطرق التي تستخدموها)؟</p> <p>- الاتصال بالمدرسة</p> <p>- آتي متاخرًا دون إبلاغ المدرسة بذلك</p> <p>- الاتصال على معلم أطفالى</p> <p>- استخدام الرسائل الخاصة عن طريق التواصل الاجتماعي</p>	<p>كيف تخبر موظفي الإدارة بأنك من الممكن أن تتأخر في اصطحاب أطفالك (حدد جميع الطرق التي تستخدموها)؟</p> <p>161 out of 206 people answered this question (with multiple choice)</p> <table border="1"> <thead> <tr> <th>الخيار</th> <th>النسبة (%)</th> <th>العدد</th> </tr> </thead> <tbody> <tr> <td>الاتصال بالمدرسة</td> <td>57.8%</td> <td>93 resp.</td> </tr> <tr> <td>آتي متاخرًا دون إبلاغ المدرسة بذلك</td> <td>36%</td> <td>58 resp.</td> </tr> <tr> <td>الاتصال على معلم أطفالى</td> <td>32.9%</td> <td>53 resp.</td> </tr> <tr> <td>استخدام الرسائل الخاصة عن طريق التواصل الاجتماعي</td> <td>27.3%</td> <td>44 resp.</td> </tr> </tbody> </table>	الخيار	النسبة (%)	العدد	الاتصال بالمدرسة	57.8%	93 resp.	آتي متاخرًا دون إبلاغ المدرسة بذلك	36%	58 resp.	الاتصال على معلم أطفالى	32.9%	53 resp.	استخدام الرسائل الخاصة عن طريق التواصل الاجتماعي	27.3%	44 resp.			
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<p>إذا كانت اجابتك ب (نعم) هل يمكنك تحديد السبب؟</p>	<p>إذا كانت اجابتك ب (نعم) هل يمكنك تحديد السبب؟</p> <p>38 out of 206 people answered this question</p> <div style="border: 1px solid #ccc; padding: 10px; min-height: 100px;"> <p>لا يوجد تواصل مباشر مع المدرسة. يعدمدون على الطفل لإبلاغ الأهل 10 days ago</p> <p>أنظمة التواصل المدرسية 11 days ago</p> </div>																		

<p>هل تجد صعوبة في التواصل مع المدرسة؟</p> <p style="text-align: center;">- لا - - نعم -</p>	<p>هل تجد صعوبة في التواصل مع المدرسة؟ 161 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>الإجابة</th> <th>النسبة (%)</th> </tr> </thead> <tbody> <tr> <td>لا</td> <td>52.8%</td> </tr> <tr> <td>نعم</td> <td>47.2%</td> </tr> </tbody> </table>	الإجابة	النسبة (%)	لا	52.8%	نعم	47.2%				
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<p>ما هو نوع التواصل الذي تحتاجه مع إدارة المدرسة؟ (حدد كل الانواع التي تحتاجها)</p> <p style="text-align: center;">- الابلاغ عن مشكلة صحية - - التأخير بالوصول - - عذر غياب - - نوع آخر من المشاكل (اجتماعية، ..) وغيرها -</p>	<p>ما هو نوع التواصل الذي تحتاجه مع إدارة المدرسة؟ (حدد كل الانواع التي تحتاجها) 161 out of 206 people answered this question (with multiple choice)</p> <table border="1"> <thead> <tr> <th>النوع</th> <th>النسبة (%)</th> </tr> </thead> <tbody> <tr> <td>الابلاغ عن مشكلة صحية</td> <td>64.6%</td> </tr> <tr> <td>التأخير بالوصول</td> <td>58.4%</td> </tr> <tr> <td>عذر غياب</td> <td>55.9%</td> </tr> <tr> <td>نوع آخر من المشاكل (اجتماعية، ..) وغيرها</td> <td>47.8%</td> </tr> </tbody> </table>	النوع	النسبة (%)	الابلاغ عن مشكلة صحية	64.6%	التأخير بالوصول	58.4%	عذر غياب	55.9%	نوع آخر من المشاكل (اجتماعية، ..) وغيرها	47.8%
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<p>إذا كان لديك أي اسباب اخرى غير مذكورة سابقاً، قم بكتابتها من فضلك</p>	<p>إذا كان لديك أي اسباب اخرى غير مذكورة سابقاً، قم بكتابتها من فضلك 23 out of 206 people answered this question</p> <p>طلب استاذان لموعد 10 days ago</p> <p>التنبيه على بعض اخلاقيات الطالبات 10 days ago</p>										
<p>هل تفضل استخدام سوار ذكي (سوار يضيء) لإعلام طفلك بوصولك بدلاً من استخدام ميكروفون المدرسة؟</p> <p style="text-align: center;">- نعم - - لا -</p>	<p>هل تفضل استخدام سوار ذكي (سوار يضيء) لإعلام طفلك بوصولك بدلاً من استخدام ميكروفون المدرسة؟ 161 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>الإجابة</th> <th>النسبة (%)</th> </tr> </thead> <tbody> <tr> <td>نعم</td> <td>88.2%</td> </tr> <tr> <td>لا</td> <td>11.8%</td> </tr> </tbody> </table>	الإجابة	النسبة (%)	نعم	88.2%	لا	11.8%				
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<p>هل تعتقد أن أطفالك قادرين على استخدامه؟</p> <p style="text-align: center;">- نعم - - لا -</p>	<p>هل تعتقد أن أطفالك قادرين على استخدامه؟ 161 out of 206 people answered this question</p> <table border="1"> <thead> <tr> <th>الإجابة</th> <th>النسبة (%)</th> </tr> </thead> <tbody> <tr> <td>نعم</td> <td>90.7%</td> </tr> <tr> <td>لا</td> <td>9.3%</td> </tr> </tbody> </table>	الإجابة	النسبة (%)	نعم	90.7%	لا	9.3%				
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أي مميزات ترغب في إضافتها إلى التطبيق تسهل عملية اصطحاب الأطفال من المدرسة والتواصل مع المدرسة؟

أي مميزات ترغب في إضافتها إلى التطبيق تسهل عملية اصطحاب الأطفال من المدرسة والتواصل مع المدرسة؟

43 out of 206 people answered this question

تسجيل حضور وغياب ابني واستاذنه واسعاري
12 days ago

يكون مجاني لكل فئات المجتمع
12 days ago

9.6 Appendix E: "Circlight" تقييم تجربة المستخدم لتطبيق

استبانة تقييم تجربة المستخدم لتطبيق "Circlight" *Table 47 "Circlight"*

#	معلومات عن المتطوع
1	اسمك؟
2	عمرك؟ 25-18 • 35-26 • 45-36 • أكبر من 45 •
3	جنسك؟ ذكر • أنثى •

4	مستوى خلفيتك التقنية؟
	• مرتفع
	• متوسط
	• منخفض

#	تقييم التجربة
1	<p>كيف تقيم تجربتك لتطبيق "Circlight"؟</p> <ul style="list-style-type: none"> ● ممتازة ● متوسطة ● جيدة ● سيئة
2	<p>أعتقد أنني أود استخدام تطبيق "Circlight" باستمرار؟</p> <ul style="list-style-type: none"> ● أواافق بشدة ● أواافق ● محايدين ● لا أواافق ● لا أواافق بشدة
3	<p>أجد أن التطبيق معقد بشكل غير ضروري؟</p> <ul style="list-style-type: none"> ● أواافق بشدة ● أواافق ● محايدين ● لا أواافق ● لا أواافق بشدة

#	تقييم التجربة
4	<p>أعتقد أن التطبيق سهل الاستخدام؟</p> <p>• أوافق بشدة</p> <p>• أوافق</p> <p>• محايدين</p> <p>• لا أافق</p> <p>• لا أافق بشدة</p>
5	<p>أعتقد أنني سأحتاج إلى دعم فني حتى أتمكن من استخدام هذا التطبيق؟</p> <p>• أوافق بشدة</p> <p>• أوافق</p> <p>• محايدين</p> <p>• لا أافق</p> <p>• لا أافق بشدة</p>
6	<p>أجد أن الوظائف المختلفة في هذا التطبيق متكاملة بشكل جيد؟</p> <p>• أوافق بشدة</p> <p>• أوافق</p> <p>• محايدين</p> <p>• لا أافق</p> <p>• لا أافق بشدة</p>

#	تقييم التجربة
7	<p>أعتقد أن هناك الكثير من التناقض في هذا التطبيق؟</p> <ul style="list-style-type: none"> ● أتفق بشدة ● أتفق ● محايد ● لا أتفق ● لا أتفق بشدة
8	<p>استطيع أن أتخيل أن معظم الناس سيستخدمون هذا التطبيق ويفهمونه بسرعة كبيرة؟</p> <ul style="list-style-type: none"> ● أتفق بشدة ● أتفق ● محايد ● لا أتفق ● لا أتفق بشدة
9	<p>لقد وجدت أن النظام غريباً جداً في الاستخدام؟</p> <ul style="list-style-type: none"> ● أتفق بشدة ● أتفق ● محايد ● لا أتفق ● لا أتفق بشدة

#	تقييم التجربة
10	<p>شعرت بثقة كبيرة خلال استخدام التطبيق؟</p> <ul style="list-style-type: none"> ● أوافق بشدة ● أواافق ● محايدين ● لا أواافق ● لا أواافق بشدة
11	<p>أحتاج إلى تعلم الكثير من الأشياء قبل أن أتمكن من استخدام هذا التطبيق؟</p> <ul style="list-style-type: none"> ● أواافق بشدة ● أواافق ● محايدين ● لا أواافق ● لا أواافق بشدة

9.7 Appendix F

Function	addParent(PN, PUserName, Email, PID, ParenPhoneNo, AltPhoneNum, Nationality, randompass, JobT, PRelativeRelation, AdminID)
Description	This function access parent collection in firebase firestore , it adds the necessary parent information such as name, email, generated and hashed password , national id etc.Then the parent account will be created , the admin will add the parent then an appropriate message will appear to the admin to confirm the addition.
Code	
<pre> */ addParent(PN, PUserName, Email, PID, ParenPhoneNo, AltPhoneNum, Nationality, randompass, JobT, PRelativeRelation, AdminID) async { CollectionReference Parents = FirebaseFirestore.instance.collection("Parent"); //for hashing String stringValue = randompass.toString(); var digest = sha1.convert(utf8.encode(stringValue)).toString(); //end of hashing Parents.add({ 'Name': PN, 'UserName': PUserName, 'Email': Email, 'NationalID': PID, 'Password': digest, 'PhoneNumber': ParenPhoneNo, 'AltPhoneNumber': AltPhoneNum, 'Nationality': Nationality, 'JobTitle': JobT, 'LateStatus': false, "RelativeRelation": PRelativeRelation, "AdminID": AdminID, }); }</pre>	

Figure 80 Add Parent Function

Function	DeleteParent(String DocId)
Description	This function access parent collection in firebase firestore, it deletes the parent from the firebase firestore. This function use parent id to delete parent information, then a confirmation message will appear to the admin to assure the deletion.
Code	
	<pre> 156 157 DeleteParent(String DocId) async { 158 CollectionReference Parents = 159 FirebaseFirestore.instance.collection("Parent"); 160 await Parents.doc(DocId).delete(); 161 } 162 </pre>

Figure 81 Delete Parent Function

Function	UpdateParent(DocId, Field, Updated)
Description	This function access parent collection in firebase firestore, it updates a particular parent information field. This function use parent id to update the required information of that particular parent. The admin then confirms the changes and an appropriate message appear to indicate that changes have been confirmed.
Code	
<pre> 01 // UpdateParent(DocId, Field, updated) async { 02 CollectionReference Parents = 03 FirebaseFirestore.instance.collection("Parent"); 04 bool IsUpdated = false; 05 06 switch (Field) { 07 case "Name": 08 await Parents.doc(DocId).update({ 09 "Name": updated, 10 }); 11 IsUpdated = true; 12 break; 13 case "username": 14 await Parents.doc(DocId).update({ 15 "UserName": Updated, 16 }); 17 break; 18 case "Email": 19 await Parents.doc(DocId).update({ 20 "Email": Updated, 21 }); 22 break; 23 case "JobTitle": 24 await Parents.doc(DocId).update({ 25 "JobTitle": Updated, 26 }); 27 break; 28 case "PhoneNumber": 29 await Parents.doc(DocId).update({ 30 "PhoneNumber": Updated, 31 }); 32 break; 33 case "AltPhoneNumber": 34 await Parents.doc(DocId).update({ 35 "AltPhoneNumber": Updated, 36 }); 37 break; 38 case "NationalID": 39 await Parents.doc(DocId).update({ 40 "NationalID": Updated, 41 }); 42 break; 43 case "Nationality": 44 await Parents.doc(DocId).update({ 45 "Nationality": Updated, 46 }); 47 break; 48 case "RelativeRelation": 49 await Parents.doc(DocId).update({ 50 "RelativeRelation": Updated, 51 }); 52 break; 53 } 54 } </pre>	

Figure 82 Update Parent Function

Function	DeleteStudent(String DocId)
Description	This function access student collection in firebase firestore, it delete's the student from the firebase firestore. This function use student id to delete student information, then a confirmation message will appear to the admin to assure the deletion.
Code	
	<pre> 61 62 DeleteStudent(String DocId) async { 63 CollectionReference Students = 64 FirebaseFirestore.instance.collection("Student"); 65 await Students.doc(DocId).delete(); 66 } 67 </pre>

Figure 83 Delete Student Function

Function	UpdateStudent(DocId, Field, Updated)
Description	This function access student collection in firebase firestore, it updates a particular student information field. This function use student id to update the required information of that particular student. The admin then confirms the changes and an appropriate message appear to indicate that changes have been confirmed.
Code	
 <pre> UpdateStudent(DocId, Field, Updated) async { CollectionReference Students = FirebaseFirestore.instance.collection("Student"); switch (Field) { case 'Name': await Students.doc(DocId).update({ 'Name': Updated, }); break; case "NationalID": await Students.doc(DocId).update({ 'NationalID': Updated, }); break; case "Nationality": await Students.doc(DocId).update({ 'Nationality': Updated, }); break; case "Class": await Students.doc(DocId).update({ 'class': Updated, }); break; case "BloodType": await Students.doc(DocId).update(['BloodType': Updated,]); break; } } </pre>	

Figure 84 Update Student Function

Function	addStudent(DocId, Name, SUserName, SNationalID, SNationality, Class, SBloodType, AdminID)
Description	This function access student collection in firebase firestore, it adds the necessary student information such as name, national id etc. The parent id will be added in student collection fields, in order to link this student to that particular parent. The admin will add the student, then an appropriate message will appear to the admin to confirm the addition.
Code	
	<pre> 67 68 addStudent(DocId, Name, SUserName, SNationalID, SNationality, Class, 69 SBloodType, AdminID) async { 70 final Student = FirebaseFirestore.instance; 71 await Student.collection("Student").add({ 72 "ParentId": DocId, 73 'Name': Name, 74 'UserName': SUserName, 75 'NationalID': SNationalID, 76 'Nationality': SNationality, 77 'Class': Class, 78 'BloodType': SBloodType, 79 'AdminID': AdminID, 80 }); 81 } 82 } //END OF CLASS 83 </pre>

Figure 85 Add Student Function

Function	Share function
Description	This function allows the admin to share the created parent account to the parent through any social media accounts that is available in the mobile, the share button will be shown only when the admin added the parent account successfully, a conformation message will appear to ensure that the admin want to share the parent created account.
Code	<pre> children: [issahre ? ElevatedButton(child: Text("مشاركة"), onPressed: () async { await showCupertinoDialog(context: context, builder: (context) => new CupertinoAlertDialog(title: new Text("هل انت متأكد من وظيفة مشاركة هذه المعلومات"), content: Column(children: [new Text("The Parent username:" + Parentusername .text), Text("The Password:" + k.toString())),],), actions: <Widget>[CupertinoDialogAction(isDefaultAction: true, child: Text("نعم"), onPressed: () { Share.share("The User Name :" + Parentusername .text + "The Password:" + k.toString()); },), CupertinoDialogAction(child: Text("لا"), onPressed: () { Navigator.of(context).push(MaterialPageRoute(builder: (context) => ParentAddform())); },),],)));); }); </pre>

Figure 86 Share Function

9.8 Appendix G

Usability

The standard definition [ISO9241] of usability is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use .Therefore, the usability of the system can be measured these metrics [47]:

- **Satisfaction:** by using a survey to get the users feedback about the System Usability Scale (SUS survey) [35] , and calculating the SUS score to see if it within acceptable range or not.
- **Efficiency:** by measuring the time that the user takes to perform a specific task, the time taken to perform the task should be in about 1 minute [33]. The time can be calculated according to this Equation:

$$\text{Task time} = \text{end time} - \text{start time}$$

- **Effectiveness:** it can be measured by calculating the number of errors detected when the user performs a specific task. The acceptable average number of errors per task is 0.7 [46]. Calculating Average number of errors using this Equation:

$$\text{Average number of errors} = \text{total number of errors}/\text{total number of tasks performed.}$$

9.9 Appendix H

Testing Questionnaires' Result:

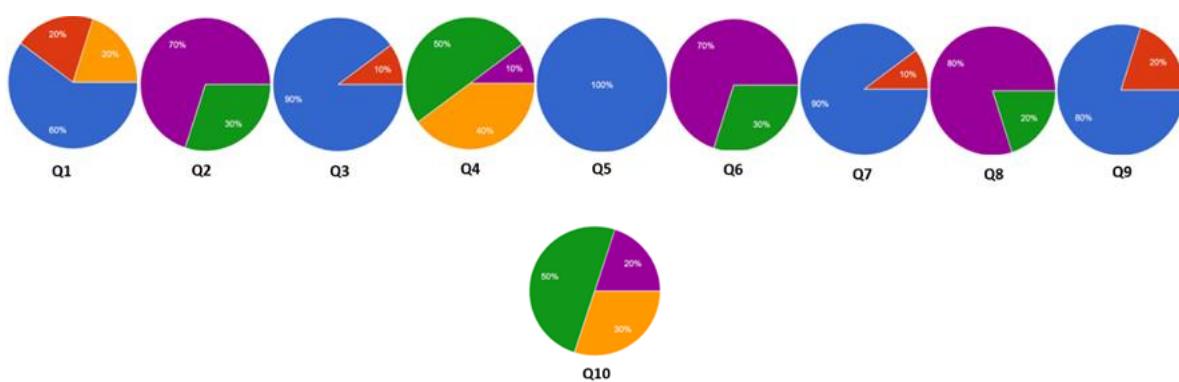


Figure 87 Testing Questionnaires' Result

9.10 Appendix I

Table 48 Security NFR

User	Correct email	Correct password	Gain the access?
User1	Yes	Yes	Yes
User2	Yes	Yes	Yes
User3	Yes	Yes	Yes
User4	Yes	Yes	Yes
User5	Yes	Yes	Yes
User6	Yes	Yes	Yes
User7	Yes	Yes	Yes
User8	Yes	Yes	Yes
User9	Yes	Yes	Yes
User10	Yes	Yes	Yes
User11	Yes	No	No
User12	Yes	Yes	Yes
User13	Yes	Yes	Yes
User14	Yes	Yes	Yes
User15	No	No	No
User16	Yes	Yes	Yes
User17	Yes	Yes	Yes
User18	Yes	Yes	Yes
User19	Yes	Yes	Yes
User20	Yes	Yes	Yes
User21	No	Yes	No
User22	Yes	Yes	Yes
User23	Yes	Yes	Yes
User24	Yes	Yes	Yes
User25	Yes	Yes	Yes
User26	Yes	Yes	Yes
User27	No	No	No
User28	Yes	Yes	Yes
User29	Yes	Yes	Yes
User30	Yes	Yes	Yes

9.11 Appendix J

49 Table Satisfaction Result

User#/Question	1	2	3	4	5	6	7	8	9	10	odd	even	total
User 1	5	1	5	3	5	1	5	1	5	3	20	16	90
User 2	4	3	5	1	4	1	5	1	4	1	17	18	87.5
User 3	5	2	5	1	5	1	5	1	4	2	19	18	92.5
User 4	5	1	5	2	5	1	5	1	5	1	20	19	97.5
User 5	5	1	5	1	5	1	4	1	5	1	19	20	97.5
User 6	5	2	5	1	5	1	5	1	5	1	20	19	97.5
User 7	5	1	5	1	5	1	5	1	5	1	20	20	100
User 8	5	1	5	1	5	1	5	1	4	1	19	20	97.5
User 9	4	1	4	2	5	2	5	1	5	2	18	17	87.5
User 10	5	1	5	1	5	1	5	1	4	1	19	20	97.5
User 11	5	1	5	1	5	1	5	1	5	1	20	20	100
User 12	4	1	4	2	5	1	5	1	5	3	18	17	87.5
User 13	5	1	5	1	5	1	5	1	5	1	20	20	100
User 14	5	1	5	1	5	1	5	1	5	1	20	20	100
User 15	5	1	5	1	5	1	5	1	5	1	20	20	100
User 16	5	1	5	1	4	1	5	1	5	1	19	20	97.5
User 17	5	1	5	1	5	1	5	1	4	1	19	20	97.5
User 18	4	2	5	1	4	1	5	1	5	1	18	19	92.5
User 19	5	1	5	1	4	1	5	1	5	1	19	20	97.5
User 20	5	1	5	3	5	1	5	1	5	2	20	17	92.5
User 21	4	1	5	1	5	1	5	1	3	1	17	20	92.5
User 22	5	1	5	1	5	1	5	1	5	1	20	20	100
User 23	5	1	5	1	5	1	4	1	5	1	19	20	97.5
User 24	4	1	5	1	4	1	5	1	5	1	18	20	95
User 25	5	1	5	1	5	1	5	1	5	1	20	20	100
User 26	5	1	5	1	5	1	5	1	4	1	19	20	97.5
User 27	5	1	5	1	5	1	5	1	5	1	20	20	100
User 28	5	1	5	1	5	1	5	1	4	1	19	20	97.5
User 29	5	1	5	1	5	1	5	1	5	1	20	20	100
User 30	5	1	5	2	5	1	5	1	5	1	20	19	97.5

9.12 Appendix K

Total	12	11	10	9	8	7	6	5	4	3	2	1	User#/Task Time
	Send Private Announcement	Send Public Announcement	Assign Student	Login	Create Parent	Add delegator	send Request	Update Parent	Update Student	Send delegation Request	Search	Pickup Student	
2.84	0.34	0.08	1.02	0.07	0.06	0.08	0.27	0.46	0.46	0.26	0.06	0.1	User1
2.8	0.36	0.06	0.44	0.06	0.03	0.08	0.25	0.07	0.45	0.2	0.05	0.06	User2
3.3	0.44	0.08	0.45	0.04	0.05	0.09	0.26	0.13	1.02	0.22	0.05	0.09	User3
3	0.51	0.13	0.46	0.07	0.06	0.11	0.25	0.09	0.44	0.24	0.04	0.08	User4
3.4	0.39	0.09	0.56	0.08	0.07	0.09	0.31	0.12	0.46	0.2	0.06	0.1	User5
3.5	0.42	0.07	1.01	0.06	0.05	0.08	0.34	0.11	0.51	0.26	0.06	0.07	User6
2.8	0.34	0.08	0.42	0.07	0.03	0.09	0.25	0.09	0.46	0.2	0.07	0.04	User7
3.2	0.37	0.09	0.43	0.1	0.05	0.08	0.3	0.09	0.51	0.21	0.09	0.06	User8
3	0.36	0.08	0.45	0.07	0.04	0.09	0.26	0.07	0.47	0.25	0.06	0.08	User9
3.1	0.39	0.12	0.47	0.09	0.11	0.08	0.25	0.08	0.45	0.21	0.08	0.06	User10
2.9	0.43	0.1	0.42	0.07	0.05	0.1	0.25	0.06	0.44	0.23	0.06	0.08	User11
2.9	0.37	0.09	0.45	0.04	0.6	0.08	0.26	0.07	0.48	0.21	0.06	0.04	User12
3.4	0.44	0.13	0.5	0.06	0.06	0.07	0.27	0.07	0.56	0.31	0.09	0.08	User13
2.9	0.38	0.07	0.44	0.05	0.04	0.09	0.22	0.1	0.46	0.23	0.05	0.07	User14
3	0.38	0.09	0.4	0.09	0.06	0.09	0.26	0.06	0.46	0.25	0.06	0.07	User15
3.7	0.34	0.08	0.56	0.05	0.11	0.11	0.34	0.06	0.57	0.26	0.06	0.1	User16
3	0.39	0.08	0.41	0.07	0.1	0.08	0.29	0.06	0.44	0.21	0.09	0.07	User17
3.1	0.37	0.11	0.45	0.09	0.15	0.1	0.25	0.07	0.46	0.23	0.04	0.06	User18
3.2	0.35	0.09	0.42	0.11	0.07	0.11	0.26	0.06	0.52	0.27	0.05	0.09	User19
2.8	0.52	0.08	0.43	0.05	0.04	0.09	0.21	0.07	0.45	0.22	0.07	0.09	User20
2.9	0.37	0.07	0.42	0.11	0.09	0.09	0.24	0.06	0.44	0.21	0.05	0.08	User21
2.9	0.39	0.09	0.44	0.05	0.04	0.1	0.26	0.06	0.48	0.21	0.04	0.07	User22
3	0.43	0.11	0.38	0.06	0.07	0.09	0.25	0.08	0.46	0.28	0.05	0.09	User23
2.9	0.37	0.13	0.42	0.04	0.06	0.08	0.25	0.05	0.47	0.25	0.06	0.09	User24
2.8	0.36	0.1	0.36	0.06	0.04	0.11	0.27	0.09	0.44	0.22	0.07	0.06	User25
3.3	0.34	0.08	1.04	0.06	0.03	0.17	0.26	0.06	0.46	0.24	0.04	0.07	User26
3	0.37	0.1	0.43	0.09	0.5	0.08	0.27	0.06	0.48	0.22	0.05	0.09	User27
3.1	0.39	0.08	0.42	0.07	0.08	0.09	0.25	0.07	0.55	0.23	0.07	0.06	User28
3.2	0.43	0.23	0.44	0.07	0.04	0.08	0.26	0.06	1:04	0.21	0.06	0.09	User29
2.9	0.37	0.14	0.41	0.06	0.09	0.08	0.24	0.08	0.46	0.24	0.04	0.07	User30
	0.390333	0.097666667	0.49833333	0.068666667	0.095666667	0.092	0.26333333	0.08866667	0.47848148	0.23266667	0.05933333	0.07533333	AVG Time per task

Figure 88 Efficiency Result

9.13 Appendix L

User	Assign Student	Login	Create Parent	Add delegator	send Request	Update Parent	Update Student	Send delegation Request	Search	Pickup Student	Send Public Announcement	Send Private Announcement	Total errors	Avg
User#	1	0	0	0	0	1	0	1	1	0	0	0	0	3 / 12 = 0.25
User	2	1	1	0	0	0	0	0	0	1	0	1	4	4 / 12 = 0.33
User	3	0	0	0	1	0	1	0	0	0	0	0	2	2 / 12 = 0.167
User	4	1	0	1	1	1	0	1	0	1	0	0	6	6 / 12 = 0.5
User	5	0	0	0	0	0	0	0	1	0	0	0	1	1 / 12 = 0.083
User	6	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	7	1	0	0	0	0	0	0	0	0	0	0	1	1 / 12 = 0.083
User	8	0	0	1	0	0	0	0	1	0	1	0	3	3 / 12 = 0.25
User	9	1	0	0	0	0	0	0	1	0	0	0	2	2 / 12 = 0.167
User	10	0	0	1	0	0	0	0	0	0	0	0	1	1 / 12 = 0.083
User	11	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	12	1	1	1	0	0	0	0	0	1	0	0	4	4 / 12 = 0.33
User	13	0	0	0	0	1	0	0	0	1	0	0	2	2 / 12 = 0.167
User	14	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	15	1	0	0	0	1	0	0	0	1	0	0	3	3 / 12 = 0.25
User	16	0	0	0	0	0	0	1	0	0	1	0	2	2 / 12 = 0.167
User	17	0	1	0	0	0	0	1	1	0	0	0	3	3 / 12 = 0.25
User	18	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	19	0	1	0	1	0	0	0	0	0	0	1	3	3 / 12 = 0.25
User	20	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	21	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	22	0	1	0	1	1	0	1	0	0	1	0	5	5 / 12 = 0.416
User	23	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	24	0	1	0	0	0	0	1	0	0	0	1	3	3 / 12 = 0.25
User	25	0	0	0	0	0	0	0	1	0	0	0	1	1 / 12 = 0.083
User	26	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	27	0	1	0	1	1	0	0	1	0	0	0	4	4 / 12 = 0.33
User	28	1	0	0	0	0	0	1	0	0	0	0	1	3 / 12 = 0.25
User	29	0	0	0	0	0	0	0	0	0	0	0	0	0 / 12 = 0
User	30	0	0	0	0	0	0	0	0	0	0	1	1	1 / 12 = 0.083
	0.23333	0.233333	0.1333333	0.1667	0.2	0.06667	0.2	0.16667	0.1	0.16667	0.0667	0.1667	AVG Error per task	

Figure 89 Effectiveness Result