Deliverable D

Group 8

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1. Introduction

As previously discussed in Deliverable C, we decided on a concept of an online interface where users can see which machines are vacant or in use when they attempt to book a machine. We evolved this idea to include a counter on the same online interface so users can see how many people are in the makerspace at one time. This system would allow the important needs we addressed in our problem statement of regulating machine usage and crowd management to be solved. We generated many ideas during our individual concept design for both booking systems, person counters and a combination of both. We then took all those ideas, categorized them and then took the best ideas out of the booking system, person counters and combination to write a description and an analysis against design criteria. We did this analysis to see how closely our chosen ideas came to the design criteria and benchmarking in Deliverable C. From those three chosen ideas we then chose a final idea to analyze and make our final project decision.

2. Categorizing Concepts

2.1 Booking System

2.1.1 Online Booking System

- Cecilia
    - Allows users to book a time slot using a system similar to Skadda that we will design through dashboard. It will have a timetable available and users can book time slots in intervals of 30min.
- James
    - Timers for 3D printers and other machines. A timer would be next to the machine and when it is in use the user will set the timer for how long they think they will be using it. The timer will connect to a UI that shows which machines are open and how long the occupied ones are going to be in use.
- Julian
    - Each machine can have an associated QR code. When scanned, the machine will be marked as “in use” for a set period of time (ranging from 15-60 minutes). There can

be links instead, if not the user does not have access to a QR code scanner

- Laura
    - Machines being connected to a software and when they're turned on the software automatically recognizes the machine as being in use and when they turn off the software recognizes them as being free. Users can track which machines are in use through an online interface
    - People using a machine in makerspace will check off which machine they're using from a list of machines on an online interface. This way people can see from home which machines are available for use by which machines have been selected as in use or out of use.

2.1.2 Offline Booking System

- Cecilia
    - This will allow users to sign into a machine by clicking a button by the machine and signing out by clicking the same button.
- James
    - When a person wants to use a machine, they go to the booking board in the room, press the button next to the machine name they are using. After 30 min of use it will need to be pressed again so that people don't forget to unbook their machines. If the machine takes a long time and doesn't need a user present, such as a printer, then the user will press the button and type how long their print is.
    - When using a machine to book it you would have to say the name of the machine you are using so that a voice recognition software can say that machine is in use. A light will go on after a certain amount of time saying the machine isn't booked anymore. To rebook it you just have to say the name of the machine again.
- Julian
    - A finger-print scanner that recognizes and stores the users' bio-identificator and assigns that machine to that person.
    - Use an existing software to allow users to book the machines and tools they need in advance.

- Thomas
    - By using a specified computer near the Makerspace to allow people to login and book whichever vacant spot. This will simplify the system and reduce costs, as server maintenance is not required.
    - Booking system using facial recognition. As a person walks in, a timer starts for that person, as that timer goes out, a staff member can be notified and regulate the use of that machine.
    - Booking system using turnstiles and student ID. As a person walks in and scans ID, a timer goes off, and as that timer approaches 0, a staff member can be warned and can regulate the machine and the student.

2.2 Person Counter

2.2.1 Motion Sensor

- Cecilia
    - Motion sensors on the ceiling will detect movements in the space. When the movement is high a busy sign can be displayed online and when the movement is low a not busy sign can be displayed.
    - A counter will be implemented with a motion sensor in front of each machine and will count the number of users using each machine specific to the machine which will help with maintenance schedule.
- Julian
    - Two motion sensors set up at the door to monitor if a customer is entering or exiting the Makerspace, and a running total is incremented or decremented according to the order in which the motion detectors go off. A staff member would monitor the counter and make any necessary adjustments.

2.2.2 Button

- Cecilia
    - When someone is using the machines, a button would be pushed, and this will allow the system to count the usage of the machine specific to the machine.

- James
    - Sign in/ out button at door of building. Allows people to sign in as they walk in rather than relying on a sensor, which could miss people when there are large groups or people standing by the door. With a button it is easier to tally up how many people are inside, and we can create a dashboard that displays the number for people before walking to the building. This way people know if it's too busy.
- Laura
    - A button at each machine that you press when you use it that counts as 1 person within the makerspace. When you're done with the machine press the button again to subtract 1 person from the amount of people within makerspace.

2.2.3 Turnstiles

- Laura
    - Turnstiles to count flow of traffic in and out of makerspace. When it turns heading into the makerspace it will count as 1 person within the makerspace when the turnstile turns heading out of the makerspace it will subtract 1 from the amount of people within the makerspace. Turnstiles will be installed at all doors in or out of the makerspace.
- Thomas
    - Connect current card system to turnstile: By connecting the current card system to a turnstile system (such as the one on a subway entrance system) we get the best of both worlds; we get to improve the current system, by just integrating a turnstile to the student card scanning system. This will offer a low price (using current card system), and an effective system.

2.2.4 Facial Recognition

- Thomas
    - Counter by Face Recognition: By using face recognition technology (such as the one found inside a smartphone), we can recognize people's faces and link them to a

student ID number, this way we know exactly who's in and out (Keys and values). By entering, the face recognition system changes the user ID's status to True, meaning that the student is inside the Makerspace. As a student leaves the opposite is done and the system sets the students status to False, meaning that the student has exited the Makerspace (this is similar to the method used inside the cashier-less amazon store). Newcomers, who's faces won't be recognized can flash their student IDs with their photos, which can create a new value associated with a key.

- Counter by Face Recognition with turnstiles: Identical to last idea, however a turnstile system is integrated, which will prohibit anybody who does not have an ID from entering.

2.2.5 Sensors other than motion

- James
  - Laser sensor for counting: Two lasers that connect with a sensor at knee level in front of the door. When the connection is broken in the order of someone walking in then the UI will display that one more person has entered the building. If the person is walking out of the building, then the connections will be broken in the other order and tell the UI that a spot has opened up.
  - Height sensor: An ultrasonic sensor, from the arduino lab, can be placed above the doorways and it will be able to tell the distance between the sensor and the top of a person's head. In the UI the height will be recorded and when a person of the exact height goes through the outdoor, then their tally will be removed.
- Julian
  - Door sensors. Monitors on the doors of the Makerspace. Depending on which side of the door is engaged, the system will know if a person in entering or leaving the room.

2.2.6 Others

- Cecilia

    - Counter using mats. Counts the footsteps on the mats when people step into the makerspace. The number will then be divided by 2 to account to in and out traffic
- Laura
    - When someone signs in using MakerRepo tap in it counts that as one person within the makerspace. When someone signs out using the MakerRepo tap out that subtracts 1 person from the amount of people within the makerspace.
- Julian
    - QR code. Put a QR code at the entrance for the Makerspace, and have patrons scan the QR code to indicate they are in the Makerspace. Instead of a QR code, there could be a link or a smartphone app where patrons would also indicate they are in the Makerspace.
- Thomas
    - Counter by manual camera scanning: By having an operator watching the live camera feed, we are able to have a manual counting system, where an operator increments and decrements the number of people inside of the Makerspace. As a person enters, the number is incremented and as a person leaves the number is decremented. This method will not be prone to machine error but could be prone to human error.

2.3 Booking system with counter

- Cecilia
    - A booking system will allow users to book out machines and while the machines are booked the users are asked to input the number of users using the room and thus a counter system is also included.
- Laura
    - Machines being connected to a software and when they’re turned on the software automatically recognises the machine as being in use and when they turn off the software recognizes them as being free. Users can track which machines are in use through an online interface as well they can track how many people are within the makerspace online using motion sensors.

3. Description and Analysis of Ideas

3.1 Booking System

3.1.1 Description

This system will use an online user interface (UI) that displays a schedule with time slots for each machine in the Maker Space. When a machine is booked for a certain amount of time, it will show on the UI that the machine is not available and users will know whether they should come to the makerspace or not. This will prevent overcrowding and keep makerspace more organized. The UI format will be similar to the one used to book rooms at the University of Ottawa for study groups. That way the system will be familiar and consistent with the rest of the school. The way the UI will work is with a survey format, where a user's name is entered, a machine is selected, and then a time slot will be selected for the time for which it'll be in use. By clicking submit the booking is registered and saved. On the UI to see what times a specific machine is booked for the user must select the specific machine in question to have the calendar system display what time slots it's been booked for. This display system will prevent the UI from being over cluttered, due to there being many machines within makerspace with many available time slots. It would be best for the system to be used for every machine, no matter if it's been booked in advance or not. If a machine is vacant while in the makerspace, once in use the user should book the machine on the system so that other users not within the makerspace can see if it's vacant or in use.

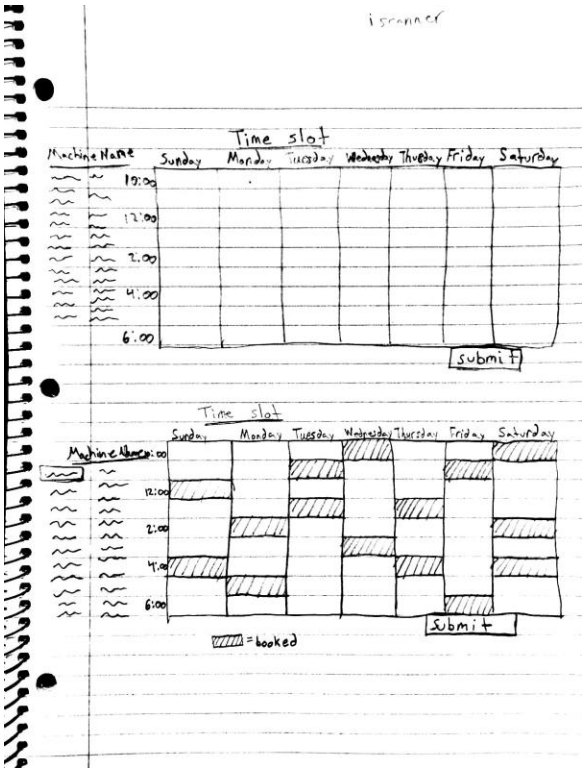

Figure 1:Online Booking System Sketch

3.1.2 Analysis against design criteria

One part of our design criteria is the functional requirements. In this section of the criteria it goes over what the booking system should be able to do to solve the problem. One thing that is important is that the UI displays a calendar and individual time slots. This way the users can get accurate and precise information about which machines are open. Having a calendar also makes it a lot more user friendly and visually pleasing. Another requirement is that the UI needs to allow users to book individual machines. The design for the UI above shows that each time the user wants to book a machine they select the machine name on the left, then select the time slot they wish to use it on the calendar. This is a very organized UI that doesn't include a lot of tabs or questions. It is also one of the criteria to be able to see what other machines are already booked. To include this, the calendar on the UI will show what time slots are already booked for each machine after selecting the machine name. The design criteria that is more specific to the final product is that it is reliable and user friendly. It is the goal of our team to make this as user friendly and as functional as possible. The final design criteria is that it is within the $100 budget.

Our team does not predict very much cost for this system because it is mostly code.

3.2 Counter system

3.2.1 Description

Using only a counter to monitor the number of people in the Makerspace would track the entrants of the space, incrementing a running total each time a new user is detected, and decrementing each time a user leaves. This can be done in a number of ways, including automatic sensors around the entrances that track the movement of people in and out of the room, or using sensors inside the room that tracks the number of people using a combination of cameras and sensors. The tracking can also be done manually by integrating CEED's existing sign-in feature or by adding a button near the entrance with which users interact when entering and leaving.

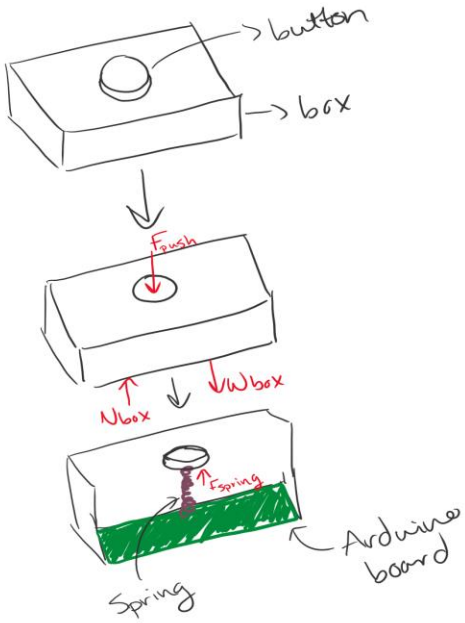

Figure 2:Person Counter Button Sketch

3.2.2 Analysis Against Design Criteria

Using buttons as counters would be a relatively cheap, unobtrusive, and simple way to count people in the Makerspace. It would be

able to track when multiple people enter or leave at the same time and not undercount. Additionally, being at ground level, it would be easiest to set up, maintain, and connect to power and ethernet. The major drawback is that it relies on patrons being responsible and pressing the button every time they enter and exit.
Automatic sensors would be the least intrusive way to count, as it does not at all rely on input from users. Some sensors would also ideally be able to count many people entering or exiting the Makerspace at some time. However, automatic sensors would be more expensive and more difficult to set up, as they require significantly more technical knowledge to create programs. Despite being more out of the way and not requiring interference from patrons, some of the sensors must be elevated to work best, which may make them difficult to set up, maintain, and supply power and ethernet.
For these reasons while our design criteria mainly supports a motion sensor idea, for simplicity we have chosen to track the number of people in the makerspace with a button attached to an Arduino board.

3.3 Combination of booking system and counter system with buttons

3.3.1 Description

This system utilizes an online interface which is connected to the machines in the Makerspace which regulates the usage of the machines through a booking system. When a user books an online appointment to use the machine, the online interface will update the machine’s schedule by adding the appointment into the calendar. Users can check the available time slots in the interface, which will prevent overcrowding. The user’s appointment will start at the person’s time of preference, which the user must select in the online interface (must be a vacant time). The appointment will end at the machine’s estimated time of completion (if machine does not have this mechanism, a default time based on the job can be used, depending on the machine). Another feature of the online interface is the display of the number of people inside the Makerspace during open hours. This will be done by using buttons inside the Makerspace. A total of two button systems will be installed inside of

the Makerspace; one system at the entrance and another set up at each exit. Every time a user presses a button at the entrance, the number of people displayed on the online interface will be incremented by 1. Each time a button press is detected at any exit, the number of people displayed will be decremented by 1.

3.3.2 Analysis Against Design Criteria

This solution offers many benefits and some disadvantages, as it combines both a booking system and a button system. The booking system meets all of its minimum requirements, as it has a calendar which users can view for bookings. It also allows users to book machines for jobs and show in the calendar which machines are booked for which times. Flaws here could be the design of the booking system; because it is an online booking system, it requires a server to run, which costs money over time, especially if cloud support is used. Furthermore, if we wish to have a passive way of determining accurate completion times for the machines. we must connect every machine to this server, which could mean a technical challenge. The buttons however, as described in the analysis for the “counter system on its own“ section above are relatively inexpensive, unobtrusive and simple method of accurately estimating the amount of people in the Makerspace, however if we want this system to work accurately, pressing the button upon arrival and exit must be strictly enforced within the Makerspace. They’d also present little technical challenge as they are relatively simple to install and maintain. When compared with the motion sensors, the buttons require more attention from the users of the Makerspace, while the motion sensors offer a more passive approach of counting the amount of people inside. However, this comes at a cost, as it would be technically more challenging, more expensive, and could more easily be inaccurate than the button system. This can be overcome with the enforcement of pressing the buttons.

4. Chosen Concept

The final concept that was chosen as the main idea is the combination of the counter and booking system. It will be an online platform that displays a counter of the users that are in the makerspace at any time. The counter will be kept through the use of buttons, users will press a button when they enter

makerspace, adding one to the counter. They will also press a different button when they exit the space, subtracting one from the counter. The number on the counter will be displayed on the main page of the online platform. The platform will also support a booking system which allows users to book time slots to use the machines. This allows users to book in advance to make sure the machine is available. The platform will also display the bookings in a calendar format of the machines booked in real-time for users at home to see if machines are in use or vacant.

The use of a button as a counter will allow for a cheap method to keep track of the use of makerspace. The data gathered from the counter will allow the users as well as the coordinators to know when the busiest times are in the makerspace. It meets the design criteria of being inexpensive and the display of the counter number makes is accessible for the users. It also combats the disadvantages that comes from the motion sensor that was previously bench marked, where the motion sensors could easily be triggered by movements other than the flow of users. The button counter requires the users to actively press the button making the count more accurate. This advantage of an accurate count will require the button to be enforced in the makerspace, just like the card sign in system. They also fulfil the design criteria of ease of use. The button method is easy to install and easy to use for the users and requires no prior training.

The booking system meets the majority of the design criteria required. It met the minimum requirement of having a calendar system of having a calendar for bookings. As seen in *Figure 1*, the booking system is arranged in a weekly format with a visual representation for time slots for the operational hours of the makerspace. A user can select timeslots required for a particular project and reserve the machines for that time period, fulfilling another design criterion. The bookings will all be displayed on the calendar which will be available online for all users to see. This system has the advantage of being easily accessible on different platforms and supports multiple users using it at the same time. However, it could be expensive running a server to support the online platform and it could also prove to be a technical challenge.

Despite these disadvantages, the combination of both concepts addresses the most design criteria and needs of the clients. This final concept allows us to fulfill the most design criteria. The integration of both concepts in theory should be a relatively easy process. The code would keep track of the number of users in the makerspace through the number of times the buttons have been pushed. This number will be displayed on the main screen of the dashboard display with the booking system. The combination of

both concepts has the advantages of both the counter system and the booking system addressing almost all the needs that CEED has.

5. Conclusion

In conclusion, this report addresses the ideas and concepts for a solution to the needs of CEED. Through analyzing the design criteria, it was determined that the best course of action was a calendar timeslot booking system with a counter display to track the usage of makerspace. This combination will regulate machine use and also address crowd management. It will allow for a greater user experience for the patrons of makerspace.