# AN INTELLIGENT LOCK SYSTEM TO IMPROVE LEARNING EFFICIENCY USING ARTIFICIAL INTELLIGENCE AND INTERNET OF THINGS

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***ABSTRACT***

*According to recent statistics, 75.4% of people with access to the internet are addicted to their phones. 78 percent of teenagers check their mobile devices at least hourly [2]. The purpose of this paper is to propose a tool that lowers users' dependence on their electronic devices. The tool named Phone Cage is created with the aim of locking electronic device for a set period of time. The application involves the user setting a specific mobile application for a specified amount of time. The phone cage provides the user a display countdown of the remaining time frame through which the locked application is inaccessible. The app provides access only when the set timer reaches the zero mark. This tool is created using Tinker cad, 3D- printer, Thunkable, Firebase console, and Raspberry Pi Zero. This will act as perfect remedy for individuals with addiction to their phones. It will also be a way for parents to control their children's use of mobile phones. Therefore, noting that a significant number of people lack self-control when it comes to cell phone usage, the cage will be of great help. The project will therefore have great impact to the community by allowing families to spend more time together and not on their phones. It will also help adults place more focus on their jobs and not on their phones.*

*The application has been tested by distributing the Phone Cage to ten randomly selected people across all age groups and conducted a qualitative evaluation of the approach. The result shows that the app has tremendously shrunk their work time and produced work with equal, if not higher quality.*

***KEYWORDS***

*Phone cage, Smartphone, Raspberry PI, IOS/Android.*

## 1. INTRODUCTION

Addiction to phone usage has grown to be a global problem faced by both male and female, young and old. Estimates show that 80% of people with smart phones spend a large proportion of their time on screen based activities. Phone overuse has various adverse side effects including psychological and physical health effects [19]. A larger percentage of young people is more affected effect when compared to the older generation. This self-imposed challenge has impacted their emotional well-being, causing poor social skills and unhealthy weight gain. Also, excessive usage of smartphones, tablets, or computers can cause the young to be addicted, decreasing overall productivity and leading to needless procrastination. Smartphone addiction is caused by an Internet overuse or addiction problem, known as "nomophobia". A study done in 2012 showed

David C. Wyld et al. (Eds): ICAIT, CBIoT, WiMo, CRYPIS, ICDIPV, CAIML, NLCA - 2022
pp. 43-56, 2022. CS & IT - CSCP 2022 DOI: 10.5121/csit.2022.121204

that in 2018, nomophobia grew from 53 percent to 66 percent [9]. However, things started getting worse in the year 2022. The Corona-virus pandemic forced people to stay indoors, increasing smartphone usage. According to a smartphone addiction poll, 99.2 percent of users experience fear and anxiety if they don't have their phone, indicating nomophobia. 37 percent of the 99.2% have mild nomophobia symptoms, 50 percent have moderate symptoms, and 13 percent have severe symptoms [13]. Nomophobia can lead to symptoms like depression, rapid heart rate, increased blood pressure, anxiety, nausea, and many more [23]. Knowing the severe cause of overusing smartphones, there is a need to start taking action to prevent phone addiction.

Nagarajan and Arthi developed a IOT smart locker. This locker is used to be a safeguard for user's personal items [7]. Both of our application used micro controller board. The project entailed components like biometric scanner and door lock system in order to make their locker more secure. Their application focuses more on security. The application can send a notification to the phone, but cannot really control the smart locker using phone. Alqahtani, Albuainaim et al. created an IOT smart locker for college [8]. They created this lock to make it more secure and convenient. The project has a keypad to open the lock if they don't have their phone. However, it uses blue tooth technique, which can be unstable. Lubans, Smith, Skinner, and Morgan created a smartphone app to help teenagers reduce screen time. The phone contained features such as 'my step', 'my workout', and 'my goal' to personalize their use of the app [24]. Since it is a digital app, the user can still have access to the phone. They can be distracted and use other entertaining app since the phone is in the user's control.

The key reason behind overuse of electronic devices is the lack of self-control [1]. For many people a phone is a luring bait. Most people do not have control of how they use their phones [20]. They feel the need to use the internet even during work or study. Following the high rate of nomophobia, there was need to find a solution hence an inspiration for creation of the Phone Cage. There is need for this app to help people curb their desire to use the phone. The application will allow individuals to operate effectively with fewer distractions.

There are various techniques used to prevent against phone addiction. They include turning on the "do not disturb" mode, silencing the phone's notifications, and deleting distracting apps. Application have been created to help set a time limit for an individual not to use their phones. However, the user can change the Screen Time settings or allow more time when the app's limit expires by typing in a pass code [17]. The proposals therefore result in lack of positive results since they assume the users already have the ability to control themselves by actively choosing to turn off their phones. In reality, people have low tendency to actually practice self-control especially when it comes to their phones. In addition, most of the available methods have easy counter-methods that undo the whole purpose: users can easily turn the notifications back on or reinstall the deleted apps. The methods are, therefore, temporary and do not result in any lasting effects. The common problem shared among all these solutions is that the phone is in the user's hand, thus, they can easily modify the setting anytime they want.

Alternative mechanism used to prevent over usage of smartphones would be more passive. Most teenagers have the experience of being restricted from their phones and or having only limited phone time. Despite them not having their phones, they are still not productive. As young adults, many teenagers desire independence [11]. They wish to gain freedom from the rules set by their parents despite lacking the skills to support themselves. Therefore, simply taking their phone away leads to reverse effects and in severe cases could worsen the parent-child relationship. Furthermore, this mechanism only works for certain age groups: specific children with phones under parental guardians. Age does not limit one from being addicted to their phone. Many adults are just as addicted to their phones and teenagers are.

Noting a need for a solution to the phone addiction, this article proposes a new idea, a physical Phone Cage. It will have a physical feature of a jail cell for electronic devices and a mobile app associated with it. The proposed method would allow users to lock their phone in a cage within a reasonably set time using the associated app. The method effectively resolves the problem on phone addiction.

The Phone Cage's unique physical feature is the ability to lock the phone making it inaccessible for the set period. Once the user places their device into the cage and starts the timer, the cage will only open when the timer goes off. This prevents users from getting distracted in the middle of their work or study as they cannot pause the locked time. The idea provides a long lasting counter for overusing phones [10]. People who use their phone simply because "it is there," now have the best solution as it prevents the user from having access to their phone whenever they wish. The 'lingering bait' is no longer able to lure the user's attention, allowing him/her to focus solely on their work.

The phone cage gives users freedom but to a certain extent. Thanks to the self-set timer feature, teenagers no longer need parents to enforce passive rules onto them. Instead, they can actively choose to lock their phones away and decide how long to lock for. This will train teenagers to decrease their dependence on electronic devices without causing issues. Phone Cage does not have an age limit [21]. Anyone from any age group can have access to this tool and have the ability to use it. It's aim is to promote productive population.

To illustrate the success of the project, two application scenarios are used. An examination of the device has been done to prove it works as expected. After rounds of trial and error, the Phone Cage worked successfully for fifty consecutive times. An illustration of the usefulness of the approach in a real-life experiment has been done. It entailed giving Phone Cage to ten of my class mass and teacher. After using the phone cage for a week, a survey was done and data collected from each user. Based on the data collected and the survey from each user, 80% of the user have increased their average worktime, and 70% of the users have increased their work quality.

The paper is organized as follows: Section 2 gives details on the challenges faced during the experiment and when designing the sample; Section 3 focuses on the details of the solutions applied in correspondence to the challenges mentioned in Section 2; Section 4 presents the relevant details of the experiment done. Finally, Section 6 gives the conclusive remarks, as well as pointing out the future work of this project.

## 2. CHALLENGES

When building the Phone Cage, the following challenges were encountered.

### 2.1. How to build the perfect phone cage

The first challenge encountered was designing the correct size and thickness of the cage and lock. The cage was designed over and over again in order to get the perfect size and thickness. The first design produced a short cage with extra spaces with poor design. We also forgot about the raspberry pi that needs to be inside the cage. After fixing the dimensions of the phone cage, we reprinted it and found out the thickness was also a problem: it breaks too easily. We decided to change the width wider and changed the 3d-printer infill density from 15% to 20% to make it stronger. Lastly, when we tried to lock the cage, we found out the lock was too tall and that it didn't fit in the slide lock. In order to fix this problem, we redesigned the lock by making the height shorter. Figure 1 is an image of all the failed attempts of the phone cage.

Figure 1. Failed attempts of the phone cage

### 2.2. How to get the correct angle for the micro servos

The project design was also faced with a problem in the micro servos. The micro servos were not as powerful to turn the exact angle as intended. In order to get the correct angle, we tested many times for the correct length of the pulse. After many attempts, we ended up having the pulse be 50 to 125 and the lock was able to perfectly slide out and lock the cage.

Figure 2. Length of the pause

### 2.3. How to let the raspberry pi run the program automatically

A problem was noted after the coding for the Raspberry Pi and the app had been completed. I had to open the raspberry pi the whole time in order to let the phone cage run the program. To solve this problem, we tried many ways to let the raspberry pi run the program automatically so my code will function at Startup. The solution lied in saving the program into raspberry pi and use of a python script program to listen to the situation.

## 3. SOLUTION

Phone Cage is a physical box that is created using Tinker cad, 3D- printer, Thunkable, Firebase console, and Raspberry Pi Zero. The main reason behind creating the cage is to;

1. Prevent/lower phone addiction
2. Increase productivity by isolating distraction.
3. Motivate one to be more self-controlled.

The tool was created using Tinkercad, 3D- printer, Thunkable, Firebase console, and Raspberry Pi Zero.

- The Tinker cad was used to design the overall Phone Cage and lock;
- The 3D- printer was used to print out the physical Phone Cage [5];
- Thunkable was used to create the Phone Cage app, which allows the user to set the time using a slide bar;
- Firebase console was used to store and conserve the data, Inspect the timestamp, unlock time, and whether the Phone Cage was locked or not
- Raspberry Pi Zero was used to control the micro servos arm to turn the slide lock

I started off my project with building the hardware prototype by 3D printing the physical box and lock. Then I created the phone cage app (timer) using Thunkable. This app allows the user to control how long they want to store their phone. The app is also able to connect and read data from the fire base. Lastly, I used a raspberry Pi to control the sliding lock and build connection between the phone cage and the firebase database. After finishing building the phone cage, we did system integration and publishing the apps [12]. The user can simply use this tool by putting their electronic into the Phone cage and user the app to set a time from1 min- 3 hours. When the user click on the "lock' button in the app, the micro servo will turn and slide in the lock. Our tool consist three main component

-a physical box to store the phone
-a app to control the lock/unlock time of the cage and connect and read data from firebase
-Raspberry Pi to control the micro servos arm angle of the lock and the connection between firebase and phone cage.

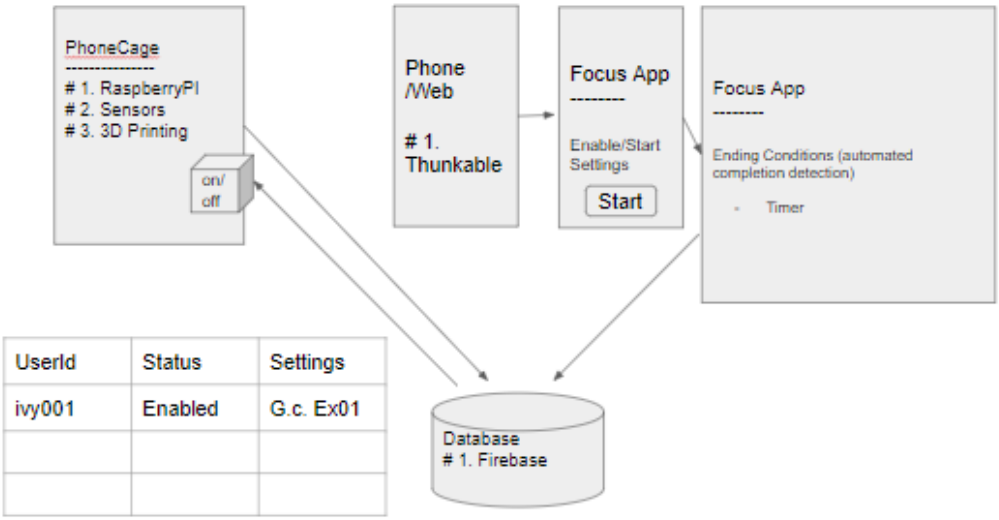


Figure 3. Overview of the system

My physical phone cage was developed by an online 3d modeling program called Tinker cad. After finishing designing the cage, I used the 3d printer and printed out the cage and the sliding lock. This step was done over and over again in order to get the perfect size and thickness of the cage and the filling for the printer.

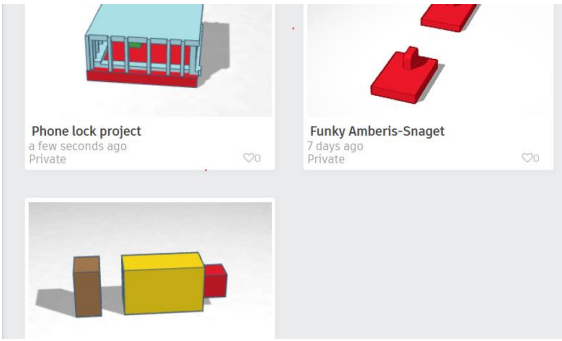


Figure 4. Online design

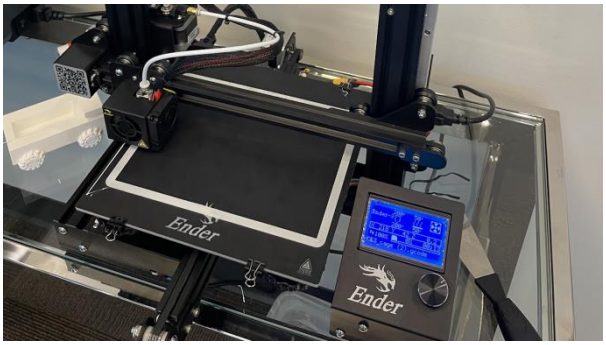


Figure 5. 3D printer

I created my application using Thunkable. In the app, the user can set the amount of time the phone is in the cage by using the slide bar. When the user clicks on the " Lock" button, the timer will start and there is no way to stop the timer. The cage will only open until the timer goes to zero. Figure 6 is an example of one of my methods, times remaining. I first set the variable to (unlock time- the time right now). If the time remaining is less than 0.1, the box will unlock so it will set the lock variable at the fire base to false. On the screen, It will return the remaining time. In the first line, I divided 3600 from the time remaining. This will show how many hours will the cage be locked. The same thing will go for minutes and seconds. I also make sure that there is a zero for the single digit. For example, instead of just showing 9 minutes, it will be 09 so the format will be correct.

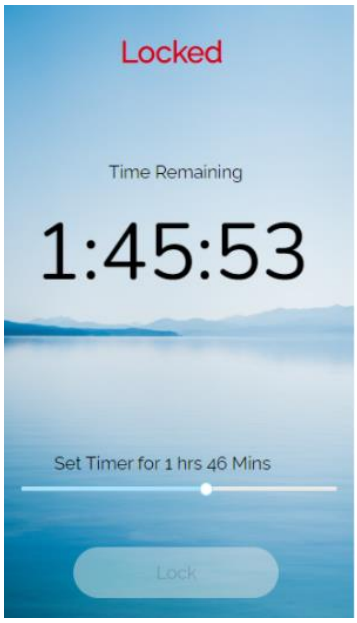


Figure 6. Screenshot of locked page

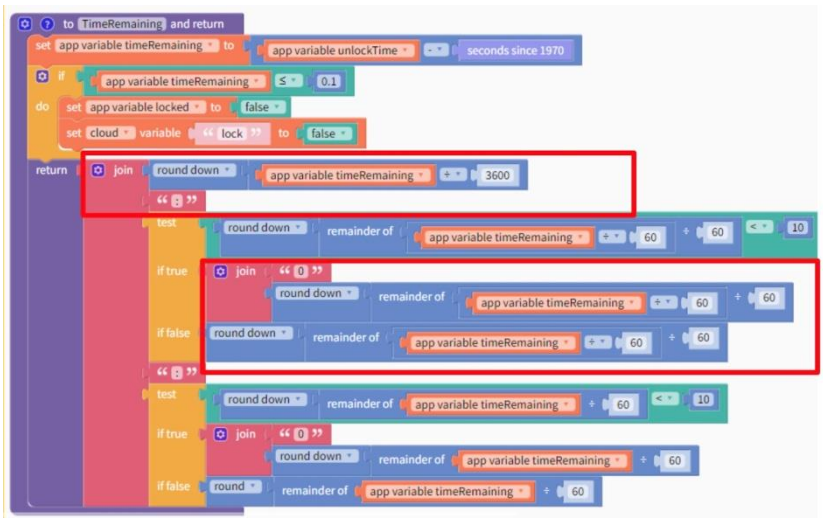


Figure 7. Screenshot of Time remaining

We connect and save data to the fire base real-time database. The fire base is linked to the Thunkable, checking the timer, timestamp, unlock time, and if the phone cage is locked or not. When the screen starts on the phone cage app, it will get the fire base data from the fire base real-time database. When the user clicks on the "start" button, the app will change and update the fire base lock in the fire base real-time database. It will display the lock variable to true, timer to (timer's value*60), timestamp to the current time, and unlock timer to (time slider's value *60 + current timestamp).

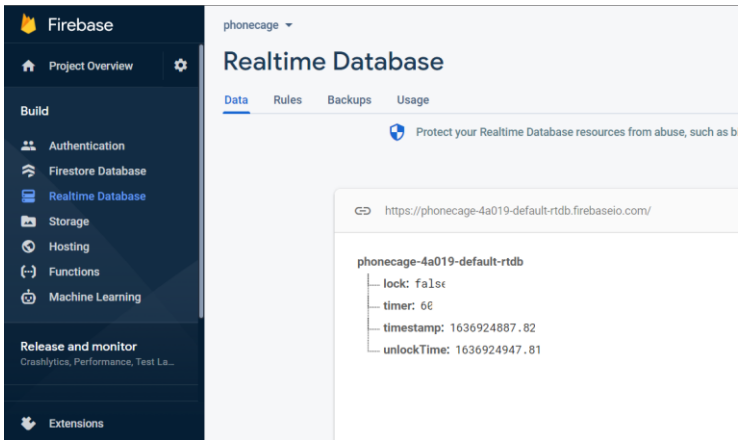


Figure 8. Screenshot of Firebase

Lastly, I used raspberry pi zero for my project. It is used to control the micro servos and the length of the pulse. The micro servos arm will turn at an angle to control the slide lock on the cage. The code below takes pin 18 to be a PWM, Pulse-width modulation, output. After setting the correct PWM mode for pin 18, It will give a clock to show how long the square wave will be. We first created a function called lockup phone and input of lockup time. We write pin 18 and give it a pulse which corresponds to the angle. In the code, the 50 and 125 is the length of the pulse. From 50 to 150, the micro servos arm will slowly increase the angle over time from opening to closing at the speed of 1, which is how smoothly the box will open/close. When the micro servo arms turn to that angle, it will result in the Phone cage being locked. When the Phone is locked, it will sleep every one second of the lock-up time. For example, if the lock time is five seconds, it will sleep five times one second. During the lock, it will also check if the micro servo is at the correct angle. After the lockup time, the length of pulse will go backward to unlock the box.

```
# set #18 to be a PWM output
wiringpi.pinMode(18, wiringpi.GPIO.PWM_OUTPUT)

# set the PWM mode to milliseconds stype
wiringpi.pwmSetMode(wiringpi.GPIO.PWM_MODE_MS)

# divide down clock
wiringpi.pwmSetClock(192)
wiringpi.pwmSetRange(2000)

delay_period = 0.01

isLocked = False

def LockUpPhone(lockuptime):
  for pulse in range(50, 125, 1):
    wiringpi.pwmWrite(18, pulse)
    time.sleep(delay_period)
  print('locked')
  for i in range(lockuptime):
    print(i)
    time.sleep(1)
    wiringpi.pwmWrite(18, 125)
  for pulse in range(125, 55, -1):
    wiringpi.pwmWrite(18, pulse)
    time.sleep(delay_period)
  print('free')
```

Figure 9. Screenshot of code

## 4. EXPERIMENT

To evaluate the success of my application, we varied the result with two different experiments. Experiment 1 tested the function of the application by doing repeat testing. Experiment 2 proved the success of decreasing smartphone use by using real-life experiments.

### 4.1. Experiment 1

The first experiment was conducted by testing the phone cage fifty times. We put my phone into the phone cage and locked it for 1-5 minutes. We then record how long the phone is locked and the result on a spreadsheet listed below (table 1). As a result, during the fifty-time testing, the phone cage was working as it is expected. We tried different lengths in locked time and each time, the phone remained locked until the timer hits zero. This experiment proves the application function adequately.

Table 1. Result of Experiment 1

| Trial # | Lock Period | Success/Fail | 18 | 1 min | Success | 36 | 3 min | Success |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 min | Success | 19 | 5 min | Success | 37 | 4 min | Success |
| 2 | 2 min | Success | 20 | 2 min | Success | 38 | 1 min | Success |
| 3 | 5 min | Success | 21 | 3 min | Success | 39 | 1 min | Success |
| 4 | 1 min | Success | 22 | 4 min | Success | 40 | 2 min | Success |
| 5 | 1 min | Success | 23 | 2 min | Success | 41 | 1 min | Success |
| 6 | 2 min | Success | 24 | 1 min | Success | 42 | 4 min | Success |
| 7 | 1 min | Success | 25 | 1 min | Success | 43 | 3 min | Success |
| 8 | 1 min | Success | 26 | 2 min | Success | 44 | 1 min | Success |
| 9 | 3 min | Success | 27 | 1 min | Success | 45 | 1 min | Success |
| 10 | 1 min | Success | 28 | 1 min | Success | 46 | 3 min | Success |
| 11 | 2 min | Success | 29 | 3 min | Success | 47 | 2 min | Success |
| 12 | 2 min | Success | 30 | 2 min | Success | 48 | 4 min | Success |
| 13 | 1 min | Success | 31 | 1 min | Success | 49 | 1 min | Success |
| 14 | 5 min | Success | 32 | 2 min | Success | 50 | 5 min | Success |
| 15 | 1 min | Success | 33 | 1 min | Success | | | |
| 16 | 1 min | Success | 34 | 1 min | Success | | | |
| 17 | 3 min | Success | 35 | 5 min | Success | | | |

## 4.2. Experiment 2

The second experiment was conducted by giving Phone cage on ten randomly selected sample users from my high school (teachers and students). We first recorded the average time they need working on homework each day after school and the quality of their work. After a week of using Phone cage each time they are operational, we surveyed each user again through their work time and whether the quality of their work increased, decreased, or remained the same.

Statistics show that 80% of the users indicate a decrease in their average work time. Of those, 50% indicate a drastic increase in efficiency as their work time decreased by more than ⅓ of their usual work time.

Table 2. Result of Experiment 2

| People | Before Phonecage Average work time (Hrs) | After Phonecage Average work time (Hrs) |
|---|---|---|
| 1 | 1.5 | 1 |
| 2 | 3 | 3 |
| 3 | 2.5 | 2.25 |
| 4 | 3.25 | 3 |
| 5 | 2 | 1 |
| 6 | 4 | 2.5 |
| 7 | 4.75 | 3.75 |
| 8 | 4 | 3.75 |
| 9 | 3.5 | 3.5 |
| 10 | 1 | 0.5 |

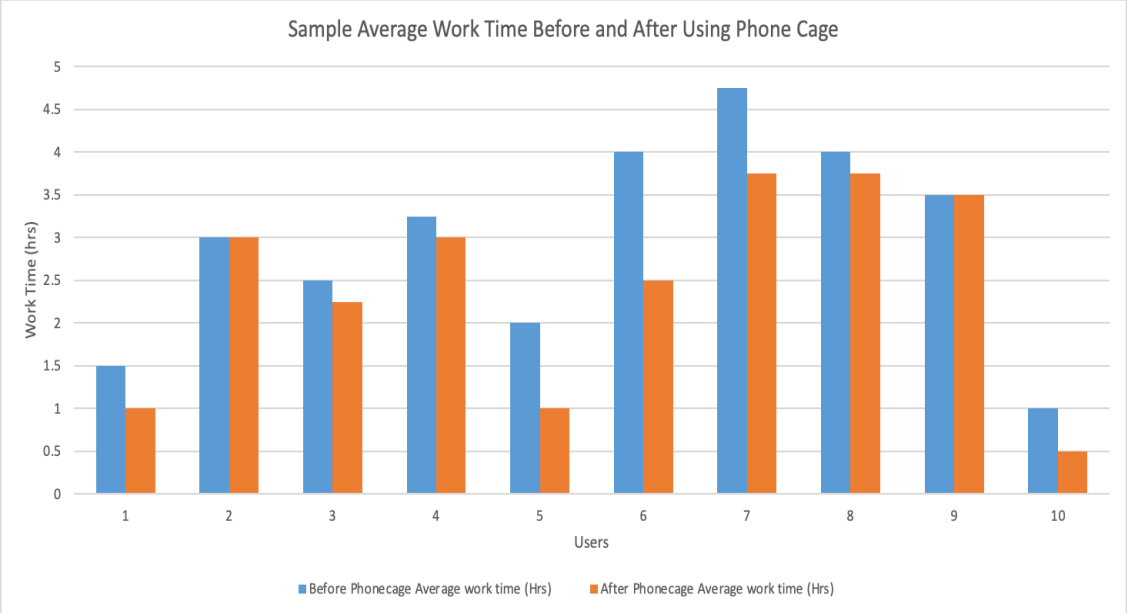


Figure 10. Chart 1 of Experiment 2

Further surveys about the quality of their work also show that 70% of the sample users admit their work quality increased after using Phone cage. The increase in quality could be demonstrated by fewer missed problems and higher performance in exams due to augmented focused study time.

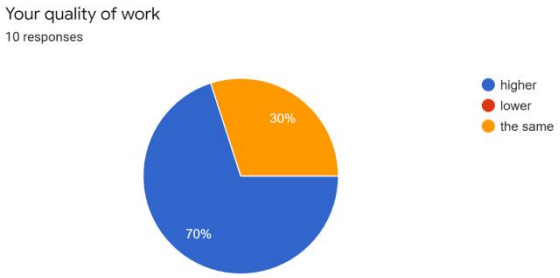


Figure 11. Chart 2 of Experiment 2

According to my own statistics, 8 out of 10 sample users we randomly selected indicate a decrease in their average work time. This significant number of users admitting positive outcomes using our Phone cage exceeded our expectations. We were confident that at least 50% of the sample would find Phone cage useful. Our data not only supports that, but also exceeds the expectations. Of the 8 that admit a decrease in their average work time, 50% indicated a drastic increase in efficiency as their work time decreased by more than ⅓ of their usual work time. (Table 2 & Figure 10) This shows the success of our phone cage to a greater extent. The sizable decrease in work time proves our point about people wasting time on meaningless electronics. Locking away phones at specific times truly boosts our sample's working efficiency. Findings from the data agrees with our central idea of decreasing the use of phones to increase people's ability to concentrate, thus producing better work at shorter times. Finally, surveys concerning the quality of work also show that 70% of the sample users admit their work quality increased after using Phone cage. The increase in quality could be demonstrated by fewer missed problems

and or higher performance on exams due to more focused study time. These line up with our expectation as we firmly believe separating useless electronics from working life will drastically increase the quantity and quality of work we get done under a specific frame of time.

## 5. RELATED WORK

Nagarajan and Arthi proposed the creation of an IOT smart locker dealing with security systems. It was to be applied both at home and in offices following the rising number of thefts. To provide security, the locker idea was aimed at protecting people together with their valuables [7]. Despite the proposed system being a high tech one, the team aimed at designing a low cost locker, one that could be affordable to every person in need since security would benefit all people despite their wealth. The system consists of a biometric scanner, an Arduino, piezoelectric sensor and an electromagnetic door lock system. Nagarajan and Arthi proposed a system that was pretty easy to implement and affordable hence reachable to all.

In an attempt to help people get more family time, Pamolon manufactured an easy to assemble phone prison. The project idea was aimed at improving interpersonal interactions by locking cell phones in a cell phone prison [14]. The prison was designed like a cell with a padlock and a railing. It contained a slotted bottom to allow the phone to stand neatly. The prison was not just designed for children but all individuals including adults. It had the capability of holding 6 mobile phones. It was designed in a secure way, temper proof to ensure that the phones could not be taken out unless the locker is unlocked. It contained a security locking mechanism, one that showed every times someone had accessed it. It was measured at 15 x 13 x 19cm hence spacious enough for all types of phones [22]. However, the intended phone cage to be designed will be an upgrade of this since it will incorporate a timer.

David Lubans together with his team came up with a smart phone application aimed at promoting physical activities and reducing screen time among young people. The application was created to assist in delivery of face to face obesity prevention program named Active Teen Leaders Avoiding Screen time otherwise known as ATLAS. The application was guided by social cognitive and self-determination theory [17]. It was evaluated using 361 boys from 14 different secondary schools. Following completion of the project, a group of the participants participated in an evaluation questionnaire to provide their personal perceptional of the program's performance and their experience with it. They also listed challenges encountered when using the application.

ATLAS was a multi-component and school based program. It was created with the main target being adolescent boys from low income communities and with the risk of being obese due to more screen time and lack of physical activities. The study had an ethics approval obtained from the Department of Education, the community and University of Newcastle. Majority of those who participated in using the application reported having moderate satisfaction with ATLAS and its features. However, an issue rose showing the need for more training since a significant number of people reported struggling with how to use the application. The ATLAS idea was a great one, however the phone cage one is an even better one since it is not just intended for young boys but all people in general despite their age.

## 6. CONCLUSIONS

To sum up my paper, my Phone cage is designed to help children, teenagers, and students and adults. It helps them work productively by limiting the use of electronics. I hope to use this project to give people just like me a motivation to change our habits of overusing phones. First in

my project, I use an online 3d modeling program called Tinker cad to design my overall phone cage and the lock. After finishing designing the cage, we used the 3d printer and printed out the physical cage and the sliding lock. This step was done over and over again in order to get the perfect size and thickness of the cage and the filling for the printer. Next, we created the app by Thunkable which lets the user can set the amount of time the phone is in the cage by using the slide bar. We connect and save data to the fire base real time database [6]. The fire base is linked to the thinkable, checking the timer, timestamp, unlock time, and if the phone cage is locked or not. Lastly, we used raspberry pi zero for my project [15]. The micro servos arm will turn at an angle to control the slide lock on the cage. We varied the effectiveness of the result by using two distinct experiments. The first experiment proves the quality of the phone cage. The second experiment proves the positive effects on the user. The two experiments prove that the phone cage is a reliable tool for the user to work more efficiently by lowering the work time and improving the efficiency. The project is therefore significant to the community since it can be used as a fun way for parents to restrict their children. It allows the children to focus on important activities such as homework and bonding with family.

There project has some limitations. First, since it is a physical phone cage, its functionality cannot be compared to that of a portable digital app. The user has to have the physical phone cage and the app in order to make this project operate normally. Also, there is only one feature for my app. Instead of just having a simply timer, I hope to create more creative conditions to open the phone cage. Lastly, I wish to add more functions for this physical phone cage. Instead of just being a simple box that is printed from the 3-d printer, I wish I can design a method that hits two birds with one stone.

I think of making tasks using my newly designed app. For example, the box will only unlock when students turn in an assignment to google classroom or finish writing 100 words on their essay. This not only motivates the student to work harder, but also reduces the boredom linked to the timer. For the physical box, I was thought of adding a portable charger or invisible shield phone sanitizer so when they use the box, they can charge and clean their phone at the same time [14].

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