**Capstone Project Portfolio**

Focus: Curbing Distraction

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# Element A: Identification and Justification of the Problem

## Executive Summary

This project aims to develop a cost-effective device to aid individuals (specifically young children and adolescents) in the completion of daily tasks which are often hindered by the distraction of mobile devices. Considering the vulnerability of autistic youth as well to the harmful effects of excessive screen time on modern devices, the design will also provide neurodivergent-friendly components as well as those for neurotypical individuals. Using visual and auditory stimulation along with a brief description of the activity to be completed, users will be gently alerted when certain tasks must be completed at designated times throughout the day. Additionally, design specifications will be made to cater to the general population’s declining attention spans due to modern technology. In other words, effective use of the device will not require much of the user’s attention to keep them up to date with their daily tasks and activities.

## Problem Statement

Worldwide attention deficit due to mobile devices is a long-persisting challenge that was first highlighted by a 2015 study by Microsoft Canada in which about half of respondents admitted difficulty sustaining attention during typical daily tasks in a domestic and professional setting (65% of such being early technology users).

Intersecting with this, those on the autism spectrum heavily rely on simple, repetitive daily routines (Howlin, 2004). This highlights the need for attention aids for both autistic people and the general, mostly neurotypical, population; more specifically, early technology users such as adolescents.

## Background

Smartphones have evolved from prototypical devices developed by small, experimental engineering projects to arguably one of the most pervasive elements of the 21st century. While phones can be useful tools for navigation, communication, and learning, their potential for distraction often outweighs their benefits. For children and adolescents in particular, mobile devices are a major source of distraction that contend with typical activities at school and home. Furthermore, these issues are exacerbated in those on the autism spectrum, for which there is a negative correlation between cell phone use and effective social function.

### Adolescents

While experts recommend limiting screen time to two (2) hours or less daily, most children and adolescents greatly exceed this limit, with the average teenager spending over eight (8) hours per day on entertainment alone.

**Figure 1**

*Average Daily Screen Times for Different Years of Age*

A graph of different colored bars

Description automatically generated with medium confidence

(Common Sense Media, 2021)

*Note*. Entertainment screen use includes time spent watching television and online videos, playing video games, using social media, browsing websites, creating content, e-reading, and other digital activities. In 2021, time spent reading ebooks was included in the total for the first time (accounting for six minutes among tweens and eight among teens), and time spent watching movies in movie theaters and using an iPod Touch were not included (these had accounted for seven minutes among tweens and six minutes among teens in 2019).

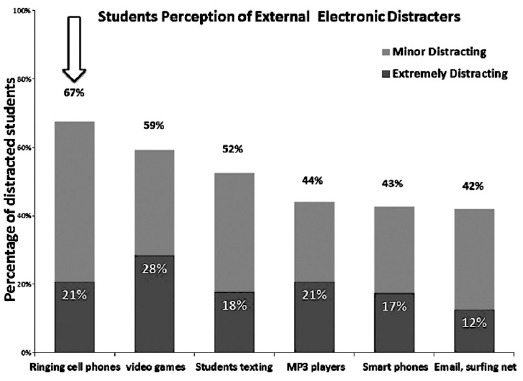
This alarming statistic provides an obvious cause for concern in the classroom, where students’ cell phones are seen as a major distractor. In fact, a 2024 study in the United States found that seventy-two percent (72%) of high school teachers identified cell phones as a major classroom distraction (Hatfield, 2024). Moreover, a post-Covid study in the United Kingdom saw eighty-four percent (84%) of primary and early years teachers agreeing that children’s attention spans were “shorter than ever” (Hall et. al 2023). While the aforementioned effects on the average child are nontrivial, there are equally powerful cases of the plight of neurodivergent individuals and screens.

Worldwide attention deficit is a long-persisting challenge that was first highlighted by a well-known 2013 study by Microsoft Canada, which claimed that average human attention has declined by over 30% within a decade, with nearly half of respondents admitting difficulty sustaining attention throughout the day (65% of such being early technology users).

Studies analyzing the harmful effects of prolonged screen time on youth show a key issue: routine. Several studies have shown a positive correlation between consistent daily routines and improved cognitive ability. However, the modern trend of declining attention spans, especially for school-aged people, makes it increasingly difficult for the average person to stay up to date with daily tasks or pay attention during routine activities such as lectures, classes, homework, etc. A study of undergraduate students in Pakistan supports this claim, with a significant number citing phones as a major or minor distractor throughout the school day. If this attention issue is combatted in high school years or even earlier, college-aged students would have established habits that are conducive to effective learning.

**Figure 2**

*Pakistani Students’ Perception of External Electronic Distractors*



(Attia, et. al., 2017)

The link between attention deficit and mobile device usage was further supported by a survey conducted in January 2025 on a sample of eighty-eight (88) students at Herschel V. Jenkins High School. While about 60% of the population preferred using cell phones for scheduling, results showed that 36.4% of respondents were distracted by their phones at least ten (10) times during a class session. Considering mobile devices’ failure to facilitate effective time management without posing a major distraction, there is a significant need for a non-cellular electronic scheduling device. Supporting this, over half of respondents admitted that they would benefit from a non-cellular scheduling device.

**Figure 3**

*Frequency of students checking mobile devices*

A pie chart with text overlay

AI-generated content may be incorrect.

*Note*. Respondents were asked how many times per class session their phones posed a major classroom/workplace distraction.

**Figure 4**

*Viability of a non-cellular scheduling device among high school students*

A red and blue circle with white text

AI-generated content may be incorrect.

*Note*. Respondents were asked whether they would benefit from a non-cellular device that keeps track of daily activities.

### Autism

The harmful nature of smartphones holds especially true for people on the autism spectrum, who hold a strong preference for routine. In observing the behaviors of several children on the autism spectrum, from ages five (5) to sixteen (16), a clear preference for routine has been established. Slight deviations from these patterns may cause meltdowns, anxiety, or other forms of external displeasure or aggression.

After thorough research, contacting people with experience handling autistic children, and conducting surveys of the general population, it is evident that there exists a need for a simple daily scheduling system for children and adolescents, whether neurotypical or on the autism spectrum who struggle with attention deficit from modern technology.

Autistic individuals often struggle with prolonged eye contact, which is often developed during early childhood with children’s parents. Naturally, sustained eye contact with parents in developmental stages would be a great help in aiding children who are genetically predisposed to the autism spectrum from regressing or falling behind their peers’ development. A Japanese study in 2022 found a strongly positive correlation between longer device screen times at one (1) year of age and autism spectrum disorder at three (3) years of age (Kushima et. al, 2022). As such, heavy usage of devices such as smartphones, televisions, and other distractors may even exacerbate existing symptoms of autism, leading to a diagnosis.

**Figure 5**

*Association Between Screen Time Exposure in Children at One Year of Age and Autism Spectrum Disorder at Three Years of Age*

A screenshot of a table

AI-generated content may be incorrect.

(Kushima et. al., 2022)

*Note.* This study was conducted in Japan and observed Japanese children.

Statements from several experts in neurodivergent childcare and professionals with extensive experience with adolescents in public school systems further supported the need for a non-cellular device for daily task management.

Dr. Cathryn Lehman, PhD, psychologist at the Center for Autism and Developmental Disorders at the University of Pittsburgh Medical Center, heavily advocates for scheduling aids for youth on the autism spectrum. Specifically, she emphasizes that such systems can be extremely simple such as, “Setting and periodically checking a timer with a moving dial or a clock with moving hands (Lehman, n.d.).”

A caretaker of autistic youth for over six years with experience educating children with learning and attention disorders (who prefers to remain anonymous) stressed the urgent need for a scheduling device to assist school-aged children as well as those on the autism spectrum. “With the focus that is lost when students spend unhealthy amounts of time on their mobile devices, there is a strong need for a device to act as a visual aid for daily time management. (Anonymous, 2025)”

Furthermore, during an interview with a K-8 teacher with over 30 years of experience (who prefers to remain anonymous), it was emphasized that a time-management device for adolescents and children with as little similarity to mobile devices as possible would be extremely effective in reducing screen times and improving focus (Anonymous, 2025).

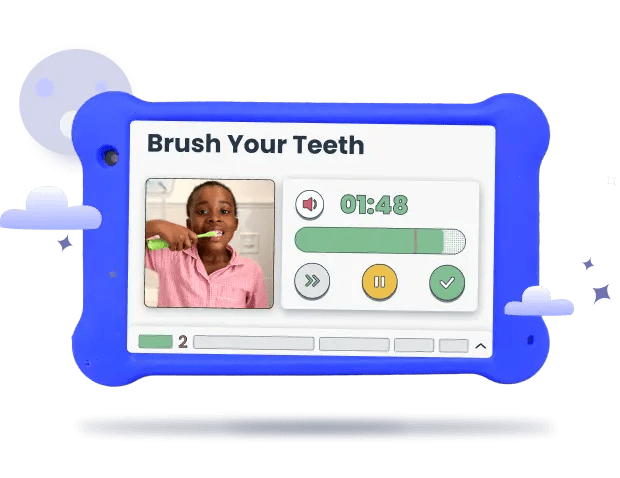
# Element B: Documentation and Analysis of Prior Solution Attempts and Competitive

Prior solutions were found via Amazon, online blog posts, and social media advertising. The strengths and weaknesses of each product were noted, with special attention to affordability, ease of use, potential for distraction, reliability in various situations, and minimalistic features. Considering the products researched, the ideal product would be affordable for the average parent, maintain operations without an internet connection, and possess minimal features so that the user is not distracted or overstimulated (in the case of neurodivergent users).

## Solution 1: Goally

**Figure 6**

*Goally*



(Goally, n.d.)

One competitor identified was “Goally,” an autism-friendly electronic visual schedule linking daily tasks to a reward-based system. However, the device’s software heavily relies on connection to a smartphone, which somewhat defeats the benefit for an independent user. Furthermore, the device’s design is a large screen, similar to an iPad, which only encourages screen addiction in youth. Finally, Goally’s 10-inch display costs $449 before shipping, and includes a yearly subscription fee, exceeding the reasonable cost for such a device. Goally’s main strength was its description of each activity to be performed and its metric for measuring the time spent doing an activity. It also included a reward-based completion system, which may be counterintuitive to its function. Mainly, the rewards-based system might encourage users to spend more time checking the device’s points rather than focusing on the task(s) at hand.

**Figure 7**

*Benchmark for Solution 1*

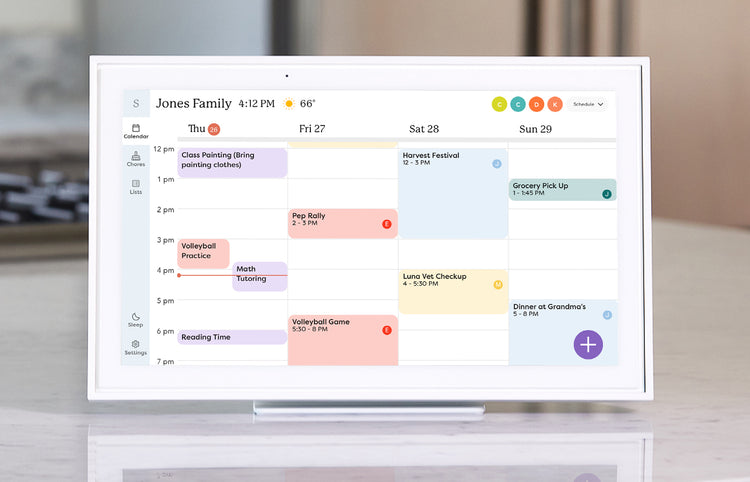
|  |  |  |
| --- | --- | --- |
| **Benchmark Category** | **Rating** | **Notes** |
| *Ease of use* | 4 | The large touchscreen tablet display is intuitive for users but may malfunction under heavy sweat or other interfering factors. |
| *Lacks Potential for distraction* | 2 | The screen as well as its vivid colors can be heavily distracting for users. |
| *Reliability* | 3 | It relies on a mobile device connection, which may not always be in proximity or connected to the internet. |
| *Minimalistic Features*  *and Operation* | 2 | Several features including the video game system are more robust than necessary, adding complications. |
| *Total* | 11 |  |

*Note.* Benchmark ratings are based on a 5-point whole number scale per category, with 5 being the highest and 1 the lowest.

## Solution 2: Skylight Calendar

**Figure 8**

*Skylight Calendar*



(Skylight, n.d.)

The “Skylight Calendar” is a 15-inch display showing calendars and chores. While it provides useful visual stimulation, the product is simply another distracting screen that serves to distract young children. While the calendar does have internet capability, its use relies heavily on an internet connection for effective use, which may not always be readily available (unreliable. Additionally, its cost of $319.99 is an obstacle for the average user.

**Figure 9**

*Benchmark for Solution 2*

|  |  |  |
| --- | --- | --- |
| **Benchmark Category** | **Rating** | **Notes** |
| *Ease of use* | 3 | The large touchscreen tablet display is intuitive for users but may malfunction under heavy sweat or other interferences. |
| *Lacks Potential for distraction* | 2 | The screen as well as its vivid colors can be heavily distracting for users. |
| *Reliability* | 2 | It relies on a mobile device connection and an active internet connection to keep track of repeating activities. |
| *Minimalistic Features*  *and Operation* | 2 | Unnecessary features like the weather and family information are overly robust. |
| *Total* | 9 |  |

*Note.* Benchmark ratings are based on a 5-point whole number scale per category, with 5 being the highest and 1 the lowest.

## Solution 3: Notion

**Figure 10**

*Notion*

A screenshot of a computer screen

AI-generated content may be incorrect.

(Notion, n.d.)

Notion is a web-based application for scheduling, planning, note-taking, etc. Operating only on mobile devices and laptops, it exposes users to other forms of distraction outside the app (e.g. social media notifications) which defeats the purpose of a medium for scheduling activities for focus.

**Figure 11**

*Benchmark for Solution 3*

|  |  |  |
| --- | --- | --- |
| **Benchmark Category** | **Rating** | **Notes** |
| *Ease of use* | 4 | Notion takes a one-stop-for-all approach so it may take some time to click through its several pages to reach the desired reminder. |
| *Lacks Potential for distraction* | 1 | The screen as well as its vivid colors can be heavily distracting for users. Being web-based, notifications from other applications are a distraction. |
| *Reliability* | 1 | It relies on a mobile device connection and an active internet connection to keep track of repeating activities. |
| *Minimalistic Features*  *and Operation* | 2 | Features like note-taking are overly robust and unnecessary for task scheduling |
| *Total* | 9 |  |

*Note.* Benchmark ratings are based on a 5-point whole number scale per category, with 5 being the highest and 1 the lowest.

# Element C: Presentation and Justification of Solution Requirements

## Design Specifications

Design specifications for the task-management product were determined based on the design of competing products and survey data from potential stakeholders. After analyzing collected data, the following design criteria were chosen (in descending order of importance): ease of use without distraction, reliability without mobile devices or the internet, and minimalistic features.

It was found that 69% of survey respondents found that repeatedly checking mobile devices was a source of distraction throughout the work/school day, with 36.8% of the surveyed population checking devices 10 or more times per day. As such, the ideal solution would not require constant attention for effective use. Furthermore, its features should be minimal to not overstimulate users or tempt them to check it throughout the day.

Competing products often relied on mobile devices for effective functionality, which could be seen as a severe limitation for a device meant to reduce screen time. Namely, “Goally” relies entirely on a connection to a mobile device to properly alert users of tasks at scheduled times. Another product, “Skylight Calendar,” only functions with a reliable internet connection, which limits the extent of its functionality in areas with unreliable internet.

After thorough consideration, it was concluded that the final solution should fulfill the following:

1. *Affordability and availability (~<$250)*

The final product should be sold at a profitable price so that the components and equipment used to construct the product are less than the final cost (i.e. the price is more than the cost of production). Additionally, the final price should be less than the exorbitant prices of competing devices, including subscription fees.

1. *A reliable system for alerting users*

The device should use visual, auditory, kinesthetic, or a combination of these stimuli to briefly direct users’ attention toward the task scheduled for a particular time, such that users will be deterred from their current preoccupancy to switch tasks.

1. *Reliable time monitoring*

The device should possess an internal clock for keeping track of world time so that alerts are sent at the appropriate time. For example, an alert scheduled for 6 PM should not sound at 5 PM.

1. *A simple user interface*

Since the device itself aims to combat shortening attention spans, the interface for marking completed activities should be simple and straightforward, such that a simple button press, scan, or other action can mark an activity as completed and require no further attention from the user.

1. *Lacks distracting features (large screens, constant flashing, etc.)*

In no way should the final product mimic the attention-grabbing features of modern mobile devices or social media. The product should be a loose aide for facilitating task completion, rather than a 24/7 attention-grabber.

# Element D: Design Concepts Generation, Analysis, and Selection

## Solution Development/Concepts

The solution development process involved assessing competitors' strengths and weaknesses, analyzing survey data, and reviewing design specifications.

### Solution 1

The first solution proposed using an Arduino Uno microcontroller connected to an LED which would flash to alert users of a scheduled activity, which would then be displayed on a liquid crystal display. The user would then mark the activity as completed with a touchless interface using an RFID tag and sensor mounted on the device.

**Figure 12**

*Solution 1 Electrical Design Sketch*

A diagram of a circuit

AI-generated content may be incorrect.

**Figure 13**

*Benchmark for Solution 1*

|  |  |  |
| --- | --- | --- |
| **Benchmark Category** | **Rating** | **Notes** |
| *Affordability and availability* | 5 | Arduino components are noted for their affordability and are available on third-party marketplaces such as Amazon and Elegoo. |
| *Reliable alert system* | 3 | While the flashing LED would alert most users, without auditory or kinesthetic stimuli, users may ignore the alert entirely (whether intentionally or unintentionally) |
| *Reliable time monitoring* | 2 | Time monitoring would use the Arduino’s internal clock that notes the starting time and counts seconds to calculate the current time. However, fluctuations in power could disrupt its internal clock. |
| *Simple user interface* | 3 | The unique tag programmed specifically for the device’s sensor poses a complex challenge when the tag is misplaced or damaged, rendering the device temporarily useless. |
| *Lacks distracting features* | 5 | No majorly distracting components or functionality |

*Note.* Benchmark ratings are based on a 5-point whole number scale per category, with 5 being the highest and 1 the lowest.

### Solution 2

The second solution, like the first, uses an Arduino Uno microcontroller to control its operations, since Arduino parts are often cheap, readily available, and simple to program. To alert users, the device uses a solid LED as well as a simple speaker that plays a musical jingle. Time tracking is performed with a real-time clock (RTC) module with an independent power supply unaffected by fluctuations in the Arduino’s voltage. The activity to be completed would be displayed as a message on a liquid crystal display module. Users would mark completed activities by pressing a tactile button mounted on the device.

**Figure 14**

*Solution 2 Electrical Design Sketch*

A graph paper with lines and text

AI-generated content may be incorrect.

**Figure 15**

*Benchmark for Solution 2*

|  |  |  |
| --- | --- | --- |
| **Benchmark Category** | **Rating** | **Notes** |
| *Affordability* | 5 | Arduino components are noted for their affordability and are available on third-party marketplaces such as Amazon and Elegoo. |
| *Reliable alert system* | 5 | The visual stimulus of the LED as well as the audible jingle from the speaker should be sufficient to alert users, especially if their attention is not turned toward the device. |
| *Reliable time monitoring* | 5 | The independent real-time clock will reliably keep track of time regardless of whether the device itself is turned on. |
| *Simple user interface* | 5 | The tactile button press for logging completed activities is simple enough for the average user to interact with and avoids complications from external parts. |
| *Lacks distracting features* | 5 | No majorly distracting components or functionality |

*Note.* Benchmark ratings are based on a 5-point whole number scale per category, with 5 being the highest and 1 the lowest.

### Solution 3

The third solution considered the possibility of a small OLED display for activity descriptions instead of a larger LCD. Using an Arduino Uno microcontroller, this device alerts users with an LED alert and describes the activity to be completed using an OLED display. Additionally, an RTC module would reliably keep track of the time. Furthermore, the use of a speaker or audio module was a possible addition to improving the alerting system.

**Figure 16**

*Solution 3 Electrical Diagram Sketch*

A diagram of a circuit

AI-generated content may be incorrect.

**Figure 17**

*Benchmark Data for Solution 3*

|  |  |  |
| --- | --- | --- |
| **Benchmark Category** | **Rating** | **Notes** |
| *Affordability* | 5 | Arduino components are noted for their affordability and are available on third-party marketplaces such as Amazon and Elegoo. |
| *Reliable alert system* | 2 | While the flashing LED would alert most users, without auditory or kinesthetic stimuli, users may ignore the alert entirely (whether intentionally or unintentionally)  Additionally, the OLED display is much too small for users to read at a reasonable distance without squinting or straining eyes. |
| *Reliable time monitoring* | 5 | The independent real-time clock will reliably keep track of time regardless of whether the device itself is turned on. |
| *Simple user interface* | 5 | The tactile button-press for logging completed activities is simple enough for the average user to interact with and avoids complications from external parts. |
| *Lacks distracting features* | 5 | No majorly distracting components or functionality. |

*Note.* Benchmark ratings are based on a 5-point whole number scale per category, with 5 being the highest and 1 the lowest.

# Element E: Application of STEM Principles and Practices

## Design Documentation

### Electrical Schematic

The electrical schematic of the final design was completed using Multisim, a professional circuit simulation software. While the software does not include pre-packaged Arduino libraries or preset Arduino components, Arduino components were made through the custom component wizard.

**Figure 18**

*Electrical Schematic*

A diagram of a circuit

AI-generated content may be incorrect.

### 3D Model for Product Casing

For safety and aesthetics, and to ensure the prototype can be mounted securely on surfaces, the addition of a casing for the product was considered. The computer-aided design (CAD) for the casing was done entirely in OnShape and the final casing was 3D printed with polylactic acid (PLA).

**Figure 19**

*CAD Model for Product Casing*

A blueprint of a box

AI-generated content may be incorrect.

**Figure 20**

### Programming the Arduino (Logic Overview)

A computer screen with white text

AI-generated content may be incorrect.

The code snipped above displays the Arduino’s main code loop. The Arduino begins by initializing the current date and time on the real-time clock (RTC), then loops through an array of structured events, each initialized before the main loop, within a struct containing a **time (hour, minute, second)** and **message (string)**. When the appropriate structured event is matched to the current time, the event’s message is displayed on the Liquid Crystal Display (LCD), a jingle is played on the device’s speaker and the LED is turned on.

## STEM Career Investigation

1. *Electronics Engineer*

Integrating Arduino microcontrollers and components requires experience with electrical components and knowledge of their functions. Therefore, an electronics professional would be necessary for combining, soldering, and implementing components to ensure cohesive functionality and durable design.

1. *Programmer*

Arduino components require some programming experience in C/C++. As such, a software engineer/programmer would be crucial for developing effective and efficient algorithms for functionality.

1. *Embedded Systems Designer*

For future improvement, custom microcontrollers could decrease the already low design costs by eliminating the extensive additional functions and components on Arduino microcontrollers.

1. *PCB Layout Designer*

A PCB designer would be useful for creating custom-printed circuit boards for an improved final product. Custom PCBs for each component could facilitate cost-effective materials and cheaper production costs.

1. *Industrial Engineer*

In mass production, industrial engineers can streamline manufacturing processes and maintain manufacturing equipment to ensure low-cost and efficient assembly-line operation.

# Element F: Consideration of Design Viability

The following criteria were used to analyze the effectiveness of the final planned design:

1. Reusability and Sustainability

The product will be charged by a replaceable nine-volt battery so that the device need not be replaced when the battery dies.

1. Ergonomics (Simple User Interaction/Interface)

The push-button used to mark completed activities allows for a simple, tactile user interface.

1. Portability/Mounting

The prototype is built on a less than 15x15 cm area in a flat-bottomed casing that allows for wall/table mounting.

Accessibility of Materials

**Figure 21**

*Proposed Materials List*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Item** | **Quantity** | **Description** | **Vendor** | **Cost** |  |
| Microcontroller | 1 | ELEGOO Arduino R3 | ELEGOO | $15.19 |  |
| Button | 1 | Tactile Button Switch 6x6x4.3mm | Amazon | $0.25/item |  |
| Liquid Crystal Display | 1 | Sunfounder I2C LCD1602 Display | Amazon | $9.99 |  |
| Audio Amplifier Resistor | 1 | 10k Ohm Resistor | Amazon | $0.05/count |  |
| LED Resistor | 1 | 330 Ohm Resistor | Amazon | $0.04/count |  |
| Real-Time Clock | 1 | DS3231 AT24C32 RTC Module Clock Timer | Amazon | $3.30/count |  |
| Blue LED | 1 | ELEGOO 3mm and 5mm Diffused and Clear Assorted LEDs | Amazon | $0.02/count |  |
| Speaker | 1 | 8Ohm Speaker Rate Input Power: 1.5W, Max Input Power: 2.0W | Amazon | $4.00/count |  |
| Male-Male Jumper Cable | 17 | 40 PCS Breadboard Jumper Wires Male to Male Multicolored | Amazon | $3.99 for 40 PCS |  |
| Female-Male Jumper Cable | 4 | 40 PCS Breadboard Jumper Wires Female to Male Multicolored | Amazon | $3.99 for 40 PCS |  |
| 400 Pin Breadboard | 1 | 400-Point Solderless Board Kit | Amazon | ~$1.33/count |  |
| 830 Pin Breadboard | 1 | ELEGOO 830 Point Solderless Breadboard Kit | Amazon | $4.33/count |  |
| 9-Volt Battery Adaptor | 1 | 9-Volt Battery Connector | Amazon | $1.90/count |  |
| 9-Volt Battery | 1 | Duracell Coppertop 9-Volt Battery | Amazon | $4.43/count |  |

# Elements G, H, and I: Construction of a Testable Prototype, Testing, and Data Analysis

## Component Functionality

The initial construction process involved a simple breadboarded design to test the individual Arduino components. An 830-pin breadboard with male-to-male jumper cables was used for the initial testing process based on the device’s typical use case.

1. An activity was scheduled for ~10 minutes after the current time.
2. The microcontroller was plugged into a computer with the new schedule for uploading.
3. Once uploaded, the microcontroller was switched to 9-volt battery power.
4. At the prescribed time, a jingle was automatically played on the speaker and a description of the activity appeared on a liquid-crystal display.
5. The activity was then dismissed by pressing the push-button interface.

The initial testing trials were run at various times throughout the day and night and activities were displayed at appropriate times without failure, proving the real-time clock's accuracy. Additionally, the prototype was left running overnight (approximately 7 hours) and remained functional. When battery power was disrupted for an extended period (1 hour or more), the real-time clock remained accurate to a ~10 second margin of error due to its internal battery power.

**Figure 22**

*Initial Breadboarded Design*

A circuit board with wires connected to it

AI-generated content may be incorrect.

Following the success of the initial design, the components were moved to the previously designed 3-D printed casing based on the following drawn layout:

**Figure 23**

*Prototype Casing Layout Sketch*

A diagram of a computer

AI-generated content may be incorrect.

The new prototype was subjected to the same testing process as before and yielded similar results.

It was noted during construction that the liquid crystal display would need to be fastened since it was not clipped directly to the breadboard like the other components. Instead, it was fastened to the casing using two self-tapping screws that held it in place.

**Figure 24**

*Prototype with Casing*

A green box with a display and wires

AI-generated content may be incorrect.

The average user would only need to interact with the upper compartment of the design, which contains the button, light, and liquid crystal display. Therefore, the lower compartment containing the remaining components was sealed off with a glass hinge that could be moved for quick access to change the real-time clock’s battery. A computer connection for schedule updating as well as a port for battery connection were also factored into the final casing design.

**Figure 25**

*Final Bill of Materials*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Item | Quantity/Size | Description | Vendor | Cost | Unit Price |
| Solid Core Copper Wire | 2 ft | 22 awg Wire Solid Core Hookup Wires | Amazon | $ 0.16 | $0.08/foot |
| Microcontroller | 1 | ELEGOO Arduino R3 | Amazon | $ 15.19 | $ 15.19 |
| Button | 1 | Tactile Button Switch 6x6x4.3mm | Amazon | $ 0.25 | $0.25/item |
| Liquid Crystal Display | 1 | Sunfounder I2C LCD1602 Display | Amazon | $ 9.99 | $ 9.99 |
| Audio Amplifier Resistor | 1 | 10k Ohm Resistor | Amazon | $ 0.05 | $0.05/count |
| LED Resistor | 1 | 330 Ohm Resistor | Amazon | $ 0.04 | $0.04/count |
| Real-Time Clock | 1 | DS3231 AT24C32 RTC Module Clock Timer | Amazon | $ 3.30 | $3.30/count |
| Blue LED | 1 | ELEGOO 3mm and 5mm Diffused and Clear Assorted LEDs | Amazon | $ 0.02 | $0.02/count |
| Speaker | 1 | 8Ohm Speaker Rate Input Power: 1.5W, Max Input Power: 2.0W | Amazon | $ 4.00 | $4.00/count |
| Arduino Prototype Shield | 1 | Breadboard Shield for Arduino Uno | Amazon | $ 4.00 | $4.00/count |
| Polylactic Acid Filament | 4.681 ounces | Flashforge PLA Filament 1.75mm | Amazon | $ 3.61 | $0.77/ounce |
| 400-pin Breadboard | 1 | 400 Solderless Plug-in Breadboard (84x55x9mm) | Amazon | $ 6.75 | $ 6.75 |
|  |  |  | Total: | $ 47.36 |  |

## 

## Testing

With the final design, the testing process outlined above in [Component Functionality](#_Component_Functionality) was carried out on four (4) high schoolers aged 15-18 and one (1) six-year-old child diagnosed with autism spectrum disorder. The same procedure as outlined above was used, with the exception that the six-year-old child’s procedure lasted several hours rather than ten minutes. Four different activities were scheduled for the child: brushing teeth, bathing, eating, and going to sleep. These activities were scheduled with 3-hour intervals in between, and the child was monitored. When the device alarmed at the appropriate time for each activity, the child paused his/her current occupation (playing games, reading, talking), moved toward the device, pressed the button to mark the activity as completed, then immediately went to complete the designated task. The high schoolers as well responded positively to the prototype and interacted with the device appropriately. Considering the consistency of these results, as well as the approval of the procedure’s validity from the child’s caretaker, the prototype was a success.

General stakeholder feedback was positive. However, multiple stakeholders suggested that the device’s wires should be organized so they are out of view, especially those connecting to the display screen.

*The test subjects opted not to be recorded or photographed.*

## Accessibility

A consideration brought up by a test subject was the visibility of the test on the liquid crystal display at various distances. As such, an additional procedure was carried out on three different test subjects to ensure scheduled activities were visible from a reasonable distance:

1. The device was powered on.
2. Subjects were equipped with a tape measure tethered to one end and told to focus their attention on the device’s screen.
3. Subjects were then told to walk away until the text on the screen was only barely visible.
4. The text was changed, and subjects were told to read the new text aloud.
5. If the text was read correctly, the distance was noted; otherwise, the procedure was repeated from step 2.

The three trials were conducted on three different subjects. The following results were obtained.

**Figure 26**

*Vision Testing Trials*

|  |  |
| --- | --- |
| **Trial #** | **Distance (m)** |
| 1 | 3.5 |
| 2 | 3.1 |
| 3 | 4.7 |
| **Average Distance (m)** | 3.8 |

# Element J: Documentation of External Evaluation

The final prototype was evaluated by an expert in the technical aspects of the project and evaluators with expertise in neurodivergent and neurotypical childcare. The project evaluation is therefore comprised of several statements from various experts, one of whom preferred to remain anonymous.

For a technical and functional perspective, the final prototype was first evaluated by Elizabeth Ewbank, a former electronics technician in the United States Navy for ten years and current Advanced Placement Calculus AB/BC teacher at Jenkins High School in Georgia, USA:

Dear Xavier,

Thank you for allowing me to review your project. Your project touched many of my areas of interest. As a petty officer in the U. S. Navy, I studied electronics and circuitry in Naval “A” and “C” schools. My work was mainly repair and instruction with aircraft simulators, but I also worked on boat simulators. I had many hours of schematic reading and circuitry testing. It was a pleasure to look at your schematics and realize just how far electronics has progressed since my time in the U.S. Navy. Your designs used modern components which allowed for a simpler design and fewer possible failure points. Given the projected demographic user group, reliability and durability are essential elements in the design process. I enjoyed the progression of designs and the improvements that were made.

As an educator of more than 30 years at the university and high school level, I have taught students of all levels with levels ranging from middle school to bachelor’s degree college students. Almost all my students now have a cell phone. Despite their ability to record due dates and assignments, cell phones have become a major distraction, especially to lower performing students, all without an increase in homework completion. The distractions are too pervasive, and I have had to ban cell phone usage in my classroom. Your task monitor is a perfect solution to combat the distractibility of the phone. I love the possibilities!

There are many characteristics that I like about your design. The visual and auditory cues, simplicity of the design, using a button to show completion of a task, the affordability, and the device’s standalone functions. Many students with ADD and ADHD have difficulty with fidgeting. Have you considered adding a fidget tool to your device? As a teacher, I have seen many bookbags that are jammed packed with everything imaginable. Have you considered an ergonometric design with a clip for bookbags?

As I read your design brief, I was very impressed. Many of the works cited were topics I had investigated myself. As a teacher, optimizing my student’s learning is very important to me. I have read studies discussing brain development, cognitive abilities, brain anatomy, and how reading a book versus screen time affects brain development. I found all your research very interesting.

Overall, your testing results are extremely promising. Durability is a key component for the success of this project. You have considered vibration, ease of use, and battery life. I would add one more test. How well does the product stand up to liquid? Electronics and liquid are generally not compatible. Have you considered making the device waterproof or at least water resistant?

Your design and goal have been met with overwhelming success. And the best part is your design is adaptable and can be continually upgraded. Your design combined with the affordability will allow a greater number of individuals to have access to your device.

Job well done Xavier!

Sincerely,

Elizabeth Ewbank

The following evaluation was completed by an anonymous educator with 17 years of experience in both elementary and early childhood settings. This teacher has taught both neurotypical students and students on the autism spectrum with varying levels of neurodivergence:

Your research is quite comprehensive and confirms many of my observations within the education sector, especially concerning dwindling attention spans because of smartphones. I believe your prototype is simple and practical. Your prototype’s lack of overwhelming features is its main strength because it is such a contrast to the attention-grabbing mobile devices that hinder classroom participation. For the final product, I strongly suggest adding the ability to play prerecorded messages that read daily schedules aloud, in order to make the device more accessible for autistic children who cannot read or only respond to a certain voice (such as their caretaker/parent). Additionally, the method for altering scheduled activities should be made more user-friendly, or a user manual should be provided for making alterations to the device’s source code. Overall, your project is a resounding success, and I am excited to see the future of your design.

# Element K: Reflection on the Design Project

Since this project was proposed, designed, researched, constructed, and tested by only one individual, several considerations from the chosen topic to the final proposed solution were decided upon without the feedback loop of a group setting. Having only one layer of decision-making was perhaps the largest weakness of the project, but this crutch was somewhat eliminated through outside feedback from classmates, experts, and potential stakeholders who provided useful feedback throughout each stage of the project. However, an individualistic approach to the project facilitated extremely efficient time management, allowing the project to stay at least one week ahead of schedule at any given period. Furthermore, the resulting course binder was extremely detailed and logical due to the benefits of continuity that stemmed from having only one writer.

The stages of prototyping were well-detailed, but extra emphasis should have been placed on improving the final prototype. For example, a Printed-Circuit Board (PCB) would have been a much more refined product than an Arduino with jumper cables. However, the final design was still a valid solution to the problem at hand.

With regards to testing, the main limitation was the availability of neurodivergent youth who were willing to test the product. This led to a limited sample size of one (1) for neurodivergent youth.

From the unbiased evaluators, the documentation was sufficient to yield a meaningful analysis that highlighted weaknesses relating to user-friendliness. Another iteration of the design would therefore have a more ergonomic casing that could attach to various surfaces and portable wear, and an easier method for changing schedules.

All in all, the project was a success, and a final product based on suggestions for the final design would most likely do well in consumer markets.

# Element L: Presentation of the Designer’s Recommendations

Based on testing and various evaluations, a revised prototype would remove many of the wires present on the final design and have a dedicated graphical user interface for changing daily schedules with ease.

Regarding the design process, while each step was well-documented, I believe working in a group would have had more benefits than I anticipated at the beginning of the project. It would have been helpful to have additional perspectives on the product, and the process would have been less stressful if the workload’s burden had been shared among various groupmates.

For a similar project, I would warn against underestimating the value of groupmates. While it is possible to complete a Capstone project alone, the collective skills and advice of a group can make the final prototype exponentially better. I am satisfied with my final prototype, but I am still curious about the improvements that would have been possible with the help of groupmates.

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