ECE 4011/ECE 4012 Project Summary

Project Title	Learning Device for the Visually Impaired
Team Members (names and majors)	Victoria Tuck, EE Alexander Booth, EE Connor Napolitano, EE Felipe Gonzalez, CmpE Azra Ismail, CmpE Nhi Nguyen, CmpE
Advisor / Section	Dr. Ayanna Howard A, IP - L8A
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Project Abstract (250-300 words)	The B.A.T. team designed and prototyped a system called the Braille Assistive Teacher that helps teach visually impaired students how to read/type braille using the six-dot system. This system helps in teaching them how to utilize the more modern "keyboard" format of the computer input interface found on many popular devices. Many of the devices that fall under the braille "keyboard" category were designed on the assumption that the user knows and is comfortable with using the keyboard format, not taking into account that it's a big difference from the six-dot system. For this reason, the Braille Assistive Teacher is invaluable to the visually impaired community. This device includes an audio feedback system that helps guide students through their use of the system. In addition, parents with no knowledge of braille are able to use this audio system to better assist their visually impaired child. The device includes six retractable pushbuttons and a hinge that converts the device from the six-dot system (3x2) to the keyboard format (1x6). This device is geared towards visually impaired middle-aged elementary school children (2nd-4th grade) but can be used by all. The focus of this team's project is on a device that children will use for additional braille practice at home instead of only at school or afterschool programs, thus supplementing users in subjects of reading, writing, and typing. This will speed up the learning process, ensuring that teachers spend the majority of their time with students on curriculum-based content and not on learning braille itself.

List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	Child Safety: ASTM F 963-11, The Standard Consumer Safety Specification for Toy Safety addresses numerous hazards that have been identified with toys. This standard influences our choice of materials for the casing as well as the design to avoid structures such as small parts and sharp edges that could pose danger to children. Accessibility standards: Web Content Accessibility Guidelines (WCAG) 2.0 covers a wide range of recommendations for making Web content more accessible. Following these guidelines makes content accessible to a wider range of people with disabilities, including blindness. We will follow these guidelines while building accessible software for our product. Curricula: Supports the Expanded Core Curriculum (ECC) for schools in Georgia. Battery Standards: The device will be handheld and battery powered. The IEEE 1625 - 2008 Standard for Rechargeable Batteries for Multi-Cell Mobile Computing Devices that specifies subsystem interface design responsibilities for each subsystem manufacturer/supplier will be followed to reduce the possibility of battery failure. I/O Ports: ● SPI:There is no formal standard for SPI, instead it is a de facto standard. The standards associated will be unique to what brand chip is selected. Some sets do not work with the JTAG (Joint Test Action group) which is used for verifying and testing printed circuit boards, from the IEEE Standard 1149.1-1990. Some do not work with the SGPIO (Serial General Purpose Input/Output), a four signal bus used between host bus adapter and back plane, which is a Small Form Factor committee (SFF-8485) standard. With whatever chip model is used, such parameters will be reviewed for what is included or not included. ● USB: bcdUSB is the standard for identifying the BCD version number. For USB 3.0, the value is 0300H. bNumConfigurations is used to describe number of configurations at the current operating speed. Standard device descriptors are included below: ○ bLength: size of descriptor in bytes. ○ bDescriptorType: Device descriptor Type ○ bcdUSB: Class code (assigned by the USB-IF) ○ bDeviceSubClass:Subclass code (assigned by the USB-IF) ○ bDeviceProtocol:Protocol code (assigned by the USB-IF). The USB of choice will have the specific standards reviewed in order to determine how much data can be transferred and what limitations it will have in the final design. ● RS-232: Depending on the model, different standards apply. We will research the standards for the the specific RS-232 model incorporated in the design in order to optimize the part. WiFi: IEEE 802.11 is a set of media access control (MAC) and physical layer specifications for implementing wireless local area network (WLAN) computer communication. We will implement this for future features that could be incorporated such as a companion web application for parents.

List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	Power: ● Battery should last at least 4 hours. ● Device will be rechargeable so it can be used again the next school day with ease. Our 6000 mAh DC power source gave us the needed power to meet these design constraints. Portability: ● Needs to hold all internal components within the 6”x4.5”x2” casing. ● Needs to weigh less than 700 grams. ● Needs to have a comfortable to use design with no sharp edges. Our final dimensions ended up being larger than what was originally desired. The final dimensions were 7.44”x2.69”x3.69”. The design of the mechanical buttons and location of the electronics would have to be revised for a more compact future iteration. Our final weight went way over what was originally expected, being 3.86 kg, which can be significantly reduced in future iterations with a more child friendly material choice (more plastic) and possible revision of lighter power source. The comfort of the design was not exactly met due to the larger dimension of the device, ending up more like a tabletop device, instead of handheld. No edges for this prototype were rounded for the increased confort. With the acrylic casing, there was no immediate harm in the laser cut corners because of the material choice. Cost: ● Overall cost should be as low as possible to create. ● Every component needs to be chosen such that they fulfill the above requirements while keeping the overall cost as low as possible. The overall cost equated to approximately $300 in parts and material. if this prototype was to sell today, the market price would approximate $900 which is lower than what we originally anticipated. The list of parts ordered met satisfactory in-budget requirements
Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	**Cost vs. Function:** ● The cost will increase with higher quality components, but the components need to satisfy minimum requirements for proper functionality ● Necessary components in the final prototype are: six push buttons, six servo motors, an mbed microcontroller, a PCB, copper tubing, wooden rods, a hinge, machine screws, washers, nuts, and acrylic for the casing material Options Considered: ● Designing a cost effective product that most students can afford with some sacrifice for higher quality (such as audio) ● Designing a high quality device that will enhance learning Solution Chosen: Cost effective design that meets minimum requirements. Our first design did not have servos since we hoped to make the buttons required completely mechanically operated. When we determined designing a mechanical button that functioned as we needed to be too large of a task, we quickly came up with a hybrid mechanical-electronic method that allowed us to get the button functionality needed with the additional requirement of six servos. This was done

	to make the prototype easier to build and design overall; in the future, it would be ideal to obtain a button that acts as needed without servos that are finicky and expensive. The final cost of parts was $306. **<u>Size and Weight vs. Durability:</u>** ● Need to ensure the device is durable to survive expected wear and tear of a classroom environment ● Also need to minimize size and weight of the device to allow students to carry the device comfortably Options Considered: ● Designing the device to ensure survivability by using stronger and heavier materials ● Designing the device to minimize size and weight Solution Chosen: Design the device with stronger and heavier materials. This was done primarily for ease of design and construction during our prototype process. This did cause the device to fall short of our goal size and weight; however, we preferred proper functionality in our prototype to prove the concept. In future iterations, the use of lighter materials is going to be a large focus. **<u>Battery vs. Size:</u>** ● With the goal size set to 6”x4.5”x2”, the device must have enough space for all of the components along with the battery. ● Requirement: Either need to have a battery pack with two voltage regulated outputs or do the separate outputs manually from one output pack Options Considered: ● Decrease the battery lifespan and choose a smaller battery ● Change the device’s size constraint ● Determine which of the two requirements to do: two output pack, or single output with 2 voltage regulators. Solution Chosen: Choose a battery that was approximately the same physical size of our PCB with components on it that had two ports on it to be able to fit all of our needs. Ideally, the device would not have six servos on it, and could run off of one port in the future if a mechanical solution is designed. The pack chosen gave us the required number of ports, an appropriate size, rechargeability, and a battery life that greatly exceeded our 4 hour goal. **<u>Mbed vs. Other Processors:</u>** ● Microprocessor needs to be powerful with accessible libraries to ensure proper functionality ● The microprocessor will need to fit within one side of the device (size 7.44” x 2.69” x 3.69”) Options Considered: ● Increase size of the device to incorporate a different microcontroller ● Use the Mbed and potentially need to add more peripherals later Solution Chosen: For the current design, there should be no need for extra peripherals (such as Wi-Fi) attached to the microcontroller. While these may be necessary in future iterations of this design, the compactness of the Mbed and

	libraries available make it the best choice for our prototype. This does come with the cost of the mbed not having the available RAM to run our code in one large program, meaning that our demo is split into three parts to be able to show our device performing the modes correctly. Going forward, a new microcontroller or more powerful mbed is to be considered under the same considerations. Raspberry Pi is certainly powerful but larger and requires certain peripherals to get the same I/O interface that the mbed has; however, a more powerful mbed is likely larger, which may increase the size along the length or width dimension if this is used.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** trade offs, interfaces, and/or interactions.	The fundamental computing aspects of our prototype that we identified as being critical to meeting our project goals and constraints were - ● Interfacing and compatibility between the various peripherals and the microcontroller ● Architecture, memory size, power management and low voltage and number of I/O pins on the microcontroller These features influenced our choice of the ARM mbed lpc1768 as the microcontroller and our choice of modules. The following modules interfacing with the microcontroller formed part of the final design: ● Servos ● Speaker ● Text-to-speech module ● SD card reader ● Pushbuttons Below are the tradeoffs involved in the choice of the above microcontroller and modules - ● I/O pins - One of the deciding factors for choosing the mbed lpc1768 was the number of pins and interfaces available. The mbed could support all peripherals without the need for extension boards. ● RAM Memory - While the RAM memory was not quite sufficient to demonstrate all the features in one program once we added the drivers for the peripherals and the buttons, we determined that it would suffice for an initial prototype because of the other benefits of using an mbed. Instead, we developed three separate programs for each of the features we wanted to demonstrate i.e. reading letters, typing letter, and typing words. ● Computation power - The ARM Cortex M3 was able to provide the performance desired and we did not face latency issues. ● Power management - The 5V output provided by the microcontroller was not able to handle the high current draw by the servos. To deal with this issue, we included two separate 5V rails on the printed circuit board. These rails were powered through two separate USB ports on the battery pack. One rail powered the mbed and the other powered all other components. The following interfaces were used by the microcontroller - ● SPI - This was used to interface with the SD card reader and read the lesson plan text file on the microSD card. ● Serial - The text to be translated to speech by the Text-to-speech module were sent as serial print commands by the microcontroller.

	We choose to include the text-to-speech module over playing recorded speech to allow for flexibility in the speech content. Recording each speech snippet would also take up memory and this approach may add latency issues because of microcontroller having to read the SD card each time. Reading the audio file each time would further take up space in RAM memory.With the text-to-speech module, the microcontroller could just send a serial print command and the work is offloaded to the text-to-speech module.
Leadership Roles	ECE 4011 Project Manager: Victoria Tuck Market Research: Alexander Booth Documentation: Felipe Gonzalez Timeline logistics: Nhi Nguyen Design Lead: Azra Ismail Technical Lead: Connor Napolitano ECE 4012 Project Manager: Victoria Tuck Webmaster: Nhi Nguyen Expo coordinator: Felipe Gonzalez Documentation: Alexander Booth Mechanical Lead: Alexander Booth Software Lead: Azra Ismail Hardware Lead: Connor Napolitano Integration and Testing Lead: Felipe Gonzalez
International Program: Global Issues	As stated in the project abstract, this device will be assistive to the blind and visually impaired in helping them learn braille. This is a problem not prevalent solely in the United States but also internationally; therefore, such a device would have numerous international applications. Although there are devices to teach braille; many are on the scale of thousands of dollars and would be a cost hindrance to many. In addition, devices on the market currently only teach how to write braille; this device would also open horizontally to allow users to learn how to type braille. In communities, locally or internationally, where no special needs teachers are available, this device would still allow a child to keep up with their classmates provided the system is translated into their native language, which should be a simple change because the current system only uses simple sets of phrases to move the student through the lesson. The cost of the device would hopefully not be a hindrance because of the low cost compared to other such devices and because multiple students could switch off using one device or pass it on to younger students as the older students grow out of needing to use the device constantly. Through this, the child will grow up and still be able to be a contributing member to society. Even in communities where special needs teachers and programs are available, this system will allow the teacher to more quickly assist the student with learning braille so that they do not fall behind in school in their younger years. In addition, parents or siblings of the student will benefit because they will be able to assist their child or sibling with learning braille, a language they themselves may not know. For older users, such a system could be used if the user has recently become blind so that they can quickly learn braille and more easily transition into a different way of life.

	The specific focus of the international plan student in this senior design team was on Germany where only 20-30% of the blind are employed; this number could be increased with better training and teaching for the blind when they are younger in order that they may have professional careers. The German braille alphabet is similar to the english with only a few extra letters and differences in the contractions; these would all be easily programmable changes. This would increase the market size for this device and as such make it more viable as an actual product.