Timing and Alert System for Students with Autism

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Problem Statement

Despite having access to assistive communication devices, our client does not communicate his need to use the bathroom to his teacher. As a result, he will urinate or defecate in his pants. Our goal is to develop a device that will be engaging and prompt our client to communicate with his teacher when he needs to go to the bathroom before it is too late. The device should be simple and intuitive so the client will not be frustrated when using it. It will also be large enough to interact with, but compact enough to leave space on the desk for regular classwork and activities. Our client has to be interested in using the device, which will be accomplished by using his favorite cartoon character and music. The device must also be durable and water-resistant to survive falls and spills in the classroom.

Background

Basilio is a high school student with autism spectrum disorder, a complex developmental disability that affects individuals in various ways [1]. Individuals with autism often have impairments with initiating and sustaining conversation, difficulties with timing and routines, and hindered motor capabilities that are noticeable in tasks like pressing small buttons [2]. Our client experiences these difficulties, which can be challenging in the classroom setting, especially in regards to using the bathroom.

Basilio often has accidents in class because he does not tell his teacher that he needs to go to the bathroom. He is capable of using the bathroom when assisted by a teacher, but has difficulty initiating communication. He has an assistive communication device called a Forte keyboard (Figure 1), which lets him type words he wishes to say; however, he does not use it because he does not find it engaging. Things that do interest our client include his favorite cartoon characters, music, and snacks.

Figure 1. Forte keyboard used by students to communicate with teacher by typing.

Aside from the device Basilio already has, current products to solve similar issues include watches and other timers that light up and/or make sounds after a certain time interval to remind the user to use the bathroom [3,4]. There are also apps for nonverbal students to tell a therapist/teacher when they need to go to the bathroom [5]. The problem with most of these devices is that they are not engaging enough, and they are too small for individuals with limited motor capabilities.

Methods and Design

To facilitate the communication between student and teacher and to help the student with the routine of going to the bathroom, we created an interactive program that prompts him about his need to use the bathroom and alerts the teacher when he indicates that he needs to go. We hope that this device will improve student-teacher communication and reduce the number of bathroom-related accidents at school.

Before discussing important features, it is necessary to understand how the device works. To start the program, the user or teacher will double click an icon on the desktop of the tablet, which launches the program. The program will start by alerting the user with music and a five-minute visual timer that their favorite cartoon character will be talking with them shortly. The cartoon character will prompt the user with questions that engage him with the device. The prompts will be straightforward, so the user stays focused. The prompts will eventually ask the client if he needs to use the bathroom.

If the client indicates that he needs to use the bathroom, the teacher's wearable buzzer vibrates. If the student answers "no" to needing to use the bathroom, the program will wait 25 minutes and then prompt the user again to indicate if he needs to use the bathroom. If the student answers "no" again, the device will wait 15 minutes to prompt, and then it will wait 5 minutes to prompt if subsequent "no" responses are given. If the user says "no" again, the teacher's buzzer will vibrate to alert her that it has been a long time since her student has gone to the bathroom. At this point, the teacher should check in with the student to see how he is doing. The purpose behind alerting the teacher after a certain amount of "no" responses is to ensure that the student's need to use the bathroom is assessed at least once an hour, as requested by his teacher. After an hour of the student saying "no," or if the user says that he needs to go, the program will loop back to the beginning and reset its timers.

If at any point the user ignores a prompt for longer than one minute, the prompt will flash and ask, "Are you still there?" If the user is unresponsive for more than 5 minutes, the program will count that as the user saying "No, I don't have to go to the bathroom," and it will check back later.

To achieve the functionality described above, the device has three main components: a touchscreen tablet that executes our code, a wearable buzzer, and protective casing.

Touchscreen Tablet/Code

The device will incorporate a commercially available 10-inch RCA Cambio Windows touchscreen tablet (Figure 2). This device was selected over other tablets for its durability, compatibility with our software, and cost. The tablet screen displays multiple prompts for the client, which their favorite cartoon character guides them through. The client responds by touching the answer on the screen. The tablet is locked into the browser so the user cannot use the device for other purposes.

Figure 2. RCA Cambio Windows Tablet

The code is more complicated than we originally anticipated because our client does not have access to Wi-Fi in his classroom, so everything had to be executed locally on the tablet. Figure 3 demonstrates how the code works within the tablet. We have written various web pages, all linked to one another, using CSS, HTML, and Javascript. These are all hosted on a local server on the tablet through Node. To make the program more user friendly, a batch file executes all of the windows commands necessary to launch Node, the local web page, and Bluetooth communication with the teacher's wearable buzzer. To start the program, all the user needs to do is double-click on the batch file icon that is on the tablet's home page.

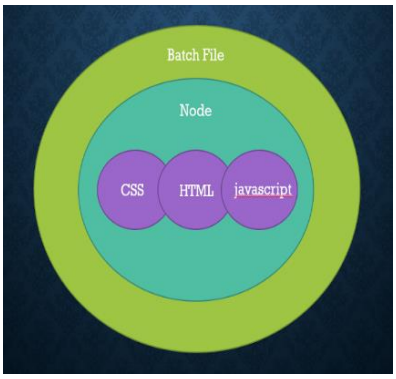

Figure 3. Code Diagram

Wearable Buzzer

When the client indicates that he needs to use the bathroom, the screen displays a prompt that says, "Great! Let's tell your teacher." When this happens, the tablet sends a Bluetooth signal through a USB Bluetooth adapter to the teacher's wearable buzzer (Figure 4). This signal causes the buzzer to vibrate, alerting the teacher that the student needs to use the bathroom.

The wearable device contains a PunchThrough Bean, a programmable electronic device equipped with Bluetooth low energy and a protoboard. A vibrating motor was soldered onto the protoboard, giving the Bean the ability to vibrate. Arduino code was uploaded to the Bean that caused the vibrating motor to buzz upon receiving a Bluetooth signal from the tablet. The Bean was chosen for this device due to its small size (1.79 x 0.80 x 0.33 inches), Bluetooth capabilities, and its protoboard. Additionally, Bluetooth communication was used instead of sending the teacher a text message or email because the student's classroom has unreliable cell phone service and internet connection. A case for the Bean was 3D printed using polylactic acid (PLA), and a commercially available watch band was attached so the device could be worn around the wrist.

Figure 4. Top: USB Bluetooth adapter; Middle: PunchThrough Bean with Vibrating Motor; Bottom: 3D Printed Case

Protective Casing

This device is used in a classroom setting, and must be able to withstand various accidents such as falling off of a desk or being spilled on. We purchased a Ram Mount Tab-Tite Universal Clamping Cradle for 10-inch tablets and a Dmax Armor screen protector to protect the tablet from falling off a three-foot desk and from spills of up to six ounces. The protective case elevates the tablet off the surface of a table, so any liquid spilled on a desk will slide under the tablet, inhibiting liquid from entering any of the USB and charging ports on the tablet. The casing takes up minimal desk space, so there is plenty of room on the desk for regular school work. Additionally, Velcro was added to the backside of the protective case and to the desk to reduce the risk of the tablet being knocked off the desk (Figure 5).

Figure 5. Top: protective case for tablet, made by Ram Mounts; with Velcro straps installed on the back; Bottom: student's desk with Velcro straps installed

Summary

With features including a touchscreen tablet, wearable buzzer, and protective casing, this device will allow Basilio to effectively communicate his need to use the bathroom before having accidents in class. Furthermore, the device is particularly appropriate for the classroom setting because it allows communication between the students and teachers to occur privately, avoiding any embarrassment. The device is also well equipped for falls and spills in the classroom, and it will hold charge for classroom time. With all of these features, the device should effectively minimize the number of accidents Basilio has at school.

Outcomes and Results

The interactive device was designed and tested for durability, water-resistance, and safety to students (sharp edges, toxicity, choking hazard). We performed testing to ensure the device was resistant to 3-ft drops (height of average desk), was protected from liquid spills, and did not pose any physical threats to the users. Functional user testing was performed to ensure that the communication abilities of the device worked well. Finally, it was determined that the device's battery could power the device for 3 hours and 20 minutes, which is shorter than the 6.5 hour school day of our clients. A portable, rechargeable power bank was provided to extend the battery life of the tablet to last the full school day.

For the tablet to be safe to use, various hazards posed by the device were identified and evaluated. We designed the device to reduce the hazards of electrical shock, falling on someone's foot, getting fingers pinched, intensity of the screen brightness, intensity of the noise from the timer, and the possibility of software or hardware malfunction. A user manual will be provided that warns against all hazards associated with the device. British Standard BS EN 12182:2015 (Technical assistive products for disabled persons – general requirements and test methods) was consulted for guiding us in designing a safe device.

A 5-point Likert scale was used to create a survey administered to our advisor and client that assessed the device's durability, functionality, and effectiveness. Results from the surveys

indicated that the device functioned as intended and that our advisor was satisfied with the device. During a full school day of testing with the design team absent, the student went to the bathroom twice during the day after using the device. Our advisor said: "This was a great experience for my student and myself. This device will open so many doors for success!"

Cost of Device

Company Name & Part Description	**Part Purpose**	**Unit Price**
RCA Cambio 10" Windows Tablet	Touchscreen interface, executed html, javascript, node.js code	$139.99
PunchThrough Bean	Electronic component in the wearable buzzer	$35.00
Ram Mount Tab-Tite Universal Clamping Cradle for 10" tablet	Protective case for tablet	$27.99
Dmax Armor Screen Protector	Protects tablet screen from spills, dust, cracks	$8.99
Digikey Vibrating Motor	Vibrating component of the wearable buzzer	$1.95
Plugable USB Bluetooth 4.0 Low Energy Adapter	Sent Bluetooth signal from tablet to wearable buzzer	$13.95
Portable 2600 mAh power bank from Five Below	Provided extra power to the tablet so that the battery would last the full school day	$5.00
Lumsing Wall-Power to USB adapter	Allows portable power bank to be recharged using wall power outlets	$5.99
FanTEK watch band	Wrist strap for wearable buzzer	$7.99
	Total Cost of the Device	**$246.85**

Significance

In summary, our client needed a device that would help him with timing and communication for using the bathroom. To meet his need, we wrote a simple and engaging program with visual timers, audio alerts, and prompts to make sure he uses the bathroom at regular intervals throughout the day, before having accidents in class. The device we have created is well suited for the school setting, as it is durable, holds charge for the school day, is safe to use, and facilitates private communication between student and teacher.

Though we have designed this device for one student who needs help with using the bathroom, it has the potential for a wide range of applications. This device could be a solution for many students with autism who need help with timing certain behaviors in school or at home. Assuming people who need this device would have access to Wi-Fi, the webpages and code we

have written could be slightly modified and published on a webpage, where it would be customizable and accessible to anyone.

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