Exploring Technology Design for Students with Vision Impairment in the Classroom and Remotely

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Teachers of the Visually Impaired (TVIs) teach academic and functional living skills simultaneously to prepare students with vision impairment to be successful and independent. Current educational tools primarily focus on academic instruction rather than this multifaceted approach needed for students. Our work aims to understand how technology can integrate behavioral skills, like independence, and support TVIs in their preferred teaching strategy. We observed elementary classrooms at a school for the blind for six weeks to study how educators design lessons and use technology to supplement their instruction in different subjects. After the observational study, we conducted remote interviews with educators to understand how technology can support students in building academic and behavioral skills in-person and remotely. Educators suggested incorporating audio feedback that motivates students to play and learn consistently, student progress tracking for parents and educators, and designing features that help students build independence and develop collaborative skills.

CCS CONCEPTS • Human-centered computing • Accessibility • Empirical studies in accessibility

Additional Keywords and Phrases: Accessibility, blind, visually impaired, teachers, children, classroom

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1 INTRODUCTION

Teachers of the Visually Impaired (TVIs) teach a wide array of academic and functional skills that are necessary for supporting students with visual impairment and encouraging their development [25]. These skills are outlined by the Expanded Core Curriculum (ECC) [24] and include traditional curriculum skills, like literacy, as well as behavioral skills, like social interaction and self-determination [32,47]. However, teaching may be overwhelming for educators who have to build activities that address several skills at once. Lueck (1999) outlines the following challenges for educators teaching ECC: (1) Addressing multifaceted educational requisites for students, (2) adapting lessons to ensure students receive individualized instruction in the areas they need, (3) and allocating sufficient instructional time for high priority areas [36,37].

Technology motivates students to engage and learn and can be a powerful tool for instruction in the areas defined by ECC [23]. However, as the digital landscape for assistive technologies is constantly changing, TVIs may spend a considerable amount of time researching how their existing tools work [3,52] while trying to keep up with new technology releases [4]. Even with new technology available, students may resist using tools that make them stick out from their peers and opt for more discrete options [4,5,16,48].

This research aims to learn how technology can meet educator and student needs, integrate with current tools in the classroom, and help educators in their academic and ECC instruction. To do this, we conducted a classroom observation at a school for the blind. We shadowed and interviewed an elementary classroom teacher, literacy teacher, and Braille specialist teacher to observe their instructional strategies and how technology supports students and teachers in the classroom.

In this work, we explore the following research questions:

1. What skills do Teachers of the Visually Impaired (TVIs) following Expanded Core Curriculum emphasize for elementary school students who are visually impaired or blind?
2. What instructional strategies do TVIs use to integrate academic literacy skills and functional/behavioral skills during a lesson?
3. What are TVIs' perspectives towards using technology in the classroom and how is the technology currently used during instructional and leisure time in the classroom?
4. How can we learn from TVIs' instructional strategies to design technology that builds both academic and behavioral skills for visually impaired children?

The contributions of this work are (1) a characterization of the goals, classroom activities, and instructional strategies educators use with visually impaired elementary school students following ECC, (2) how educators integrate technology into their instruction for literacy and functional living skills, and (3) feedback from educators on how technology can best support them in the classroom and remote education. We found that educators use academic instruction, particularly literacy, to build ECC skills such as independence and social interaction. Educators also expressed that for future classroom technology, they prioritize features that enable collaborative and independent play, teacher control over educational activities, and student progress tracking.

2 RELATED WORK

This section outlines popular instructional strategies from TVIs, an overview of toys and technology commonly used in the classroom by students with vision impairment, and previous classroom ethnography research that grounded our study design and methods.

2.1 Integrating ECC with Academic Instruction

2.1.1 An Overview of ECC

Expanded Core Curriculum (ECC) provides an instructional framework for students who are blind or visually impaired [47]. At the core of this curriculum is basic academic instruction, such as English literacy, Art, Math, Science, and History. ECC specifies additional behavioral and functional skills for students with vision impairment to develop. These include orientation, mobility, social interaction, independent living, recreation and leisure, sensory efficiency, using assistive technology, career education, self-determination, and compensatory skills like concept development and organization [41,47]. ECC derives from the Individuals with Disabilities Education Act (IDEA), which requires that schools develop individualized education programs (IEP) to improve specific skills for students with disabilities [21]. ECC is not a mandatory curriculum but has become commonplace at specialized schools for the blind, such as Perkins School for the Blind and its affiliated institutions [41].

2.1.2 Instructional Strategies for ECC

Wolffe et al. (2002) found that educators often teach ECC skills through unstructured, isolated chunks of instruction [58]. These instructional activities could vary from semi-structured discussions about the student's family members to students picking activities for the class to do. For more structured activities, educators encourage students to work on specific behavioral skills, like waving at each other or using particular facial expressions when interacting with sighted people in the classroom. The authors of this work note that instruction in ECC skills was secondary to core academic instruction and only occurred when time permitted. However, other work has found that ECC instruction integrates with schools' regular curriculum during the school day and that many schools provide additional support after school [35].

Physical education is a popular strategy for teaching each supplemental skill in ECC [34]. We can use social interaction skills as an example of this. Sapp and Hatlen (2010) define social interaction in ECC as the concepts and skills people use to interact with each other [47]. Team sports build these social interaction skills by promoting peer interaction [34]. Athletic participation encourages sportsmanship, fairness, and communication. It is also a "natural" everyday activity that educators can easily integrate ECC skills with, both in and out of the classroom.

To further study how ECC instruction integrates with daily classroom activities, we observed how educators designed specific lessons to target these skills.

2.2 Current Technology in the Classroom

Classrooms have a mix of handmade tools made by instructors and parents, commercially available toys and tangibles, and more advanced technology like Braille writers and refreshable displays. This section contextualizes the tools we observed in the classroom during our study.

2.2.1 Toys and DIY Tangibles for Braille Literacy

Educators have created affordable, Do-It-Yourself (DIY) tools for students to play games and develop spatial perception skills, particularly for Braille. These include edible Braille pizzas [26] and Braille cells crafted with play-dough [7]. The Professional Development and Research Institute on Blindness recommend that educators

and parents utilize household items, like egg cartons and cupcake tins, to create enlarged Braille cells for children to explore [7].

There is a selection of commercially available tangible toys that reinforce early literacy skills through tactile play. Many of these toys are block-based, like PlanToys Braille Alphabet A-Z [8], Swing Cell [53], Braille Caravan [11], Tack-Tiles [54], Lego Braille Bricks [10], and Uncle Goose Braille [9] and Math blocks [13]. Toy company Uncle Goose asserts that block-play helps children's cognitive, physical, and social development [56].

2.2.2 Technology for Writing and Reading

Students can use advanced typewriters, notetakers, and keyboards as efficient alternatives to traditional tools like the slate and stylus. Braille typewriters have evolved to incorporate text-to-speech software, digital displays for visual feedback, and can save student progress digitally [50]. Braille notetakers have shifted from small, personal devices to advanced tablets with powerful computing capabilities, such as the BrailleNote Touch Plus [15,22,38]. Notetakers like the Active Braille [2] and the Orbit Reader 20 [39] have refreshable Braille displays and easily connect to other devices through Bluetooth.

Hartz (2000) looked at how schools use different software and tools to teach literacy to visually impaired students [23]. This work found that technology surrounded students in the classroom and infused into the curriculum. Classrooms had computers, electronic dictionaries, refreshable Braille displays, and a Kurzweil reading machine (a scanner that converts print to speech) [12,29,30]. Students wrote, revised, and edited their work on computers with the JAWS screen reading software, speech synthesizers, and screen enlargement software [28]. Some students alternatively chose to use Braille notetakers, like the Perkins Manual Brailler, the Braille Lite, and the Braille 'n Speak [12,14,40].

Presley and D'Andrea (2009) further defined the role of assistive technology for blind or visually impaired students in the classroom [42]. The authors explained that students use technology to reinforce their learning and support their skill development in academic areas like reading, writing, and math. Students can also use technology to access a broader range of information, like electronic texts and audio and video resources. As assistive devices for reading and writing become commonplace in the classroom, students' proficiency with these devices is another expectation for what it means to be literate.

In this study, we will further explore the technology landscape of classrooms at a school for the blind, learn how teachers integrate these tools into their instruction, and gain their perspectives on the future role of technology for students.

2.3 Classroom Observation and Ethnography

Observation and ethnography became a popular research method to characterize and identify complexities within classrooms in the 1960s, with work such as Smith and Geoffrey (1968) [51], Jackson (1968) [27], and Leacock (1969) [31]. From this foundation and the work that has continued, researchers have found that classroom ethnography has the power to identify educator challenges, understand socio-cultural clashes between students and administration, and study problems that schools unknowingly perpetuate [19].

Researchers have applied classroom ethnography techniques to study how visually impaired students develop behavioral skills and technical skills. Sacks et al. (1992) use theoretical background and ethnography to explore how children who are visually impaired develop social skills [46]. The authors explained that by conducting an ethnography, they could identify classroom issues without disrupting everyday routines and

minimizing interference. From interviews and observation, this work built a case study around three students in the classroom to illustrate students' deficits in social skills, how teachers intervened with students, and the effects of the classroom environment on students' social development.

To study how visually impaired students learn music at school, Abramo and Pierce (2013) observed students and conducted semi-structured interviews [1]. The researchers triangulated data by involving multiple researchers in the investigation and by gathering data through different methods. Finally, they used open coding techniques to identify themes from the data. From this study design, authors were able to find challenges with inclusivity in music classes and identify pedagogy and modes of communication in the classroom.

Our work extends these ethnography techniques to literacy education and expanded core curriculum for visually impaired students. We ground our study design in the methods described in these studies, which we will expand on in the next section.

3 STUDY DESIGN AND METHODS

To learn how to design technology that addresses multifaceted instruction for students with vision impairment, we observed classrooms at a school for the blind. We sought to understand what values educators prioritized and how their instruction and technology use reflected these values. We ended our study with a remote interview to gather educators' final thoughts on the role of technology for in-person and online instruction.

3.1 Classroom Observation

We observed elementary school teachers and students at a school for the blind once a week for six weeks (six sessions total). We shadowed educators from the main elementary classroom, literacy class, and Braille class. We occasionally attended lunch, recess, music class, and technology class. This study entailed observing classroom activities, interviewing educators, and volunteering in the classroom. We informally interviewed students about their classroom activities and how they used their technology. However, we chose to focus on educator perspectives to learn how future technology can mirror instructional strategies.

3.1.1 Consent and Data Collection

We sent educators consent forms for data collection before our first session. We also emailed consent/assent forms to all elementary school parents. In the first session, we introduced ourselves to students as volunteers and researchers. We explained that we would observe, interview, and record students to learn about the activities they do.

In the first session, we gave students information about the study to take home to their parents. After parents and students filled out the consent/assent forms, we began official data collection during the second session. We did not collect data from students who did not assent and whose parents did not consent.

3.1.2 Class Schedule

Each classroom session was for a full school day with six class periods. The school day started at 8:30 AM and ended at 3:30 PM. Table 1 describes an average schedule for a single session. We audio and video recorded instructional activities during periods one, three, five, and six. We spent period two (Teacher Planning) with Samantha, an elementary classroom teacher. We used this time to interview teachers, reflect on specific lessons, and gather feedback for game ideas. We spent half of the lunch period alone taking notes and the

second half helping students get ready for recess and supervising recess. During class, we helped students complete classroom activities and organized materials for educators.

Elementary school students rotate between classes each period of the day. There are two elementary teachers and one teacher per other subjects. In the first period, Samantha has five students in 2nd and 3rd grade. After the first period, students go off to extracurricular classes, like music or technology. The second period is Samantha's planning period, during which she has no students. Allison, the Braille instructor, has two students in 4th and 5th grade in third-period. All elementary school students eat lunch together during fourth-period while several teachers supervise them. In the fifth period, Samantha has seven students in 4th and 5th grade. In the sixth period, literacy teacher Jackie has three students in 4th and 5th grade. All of Jackie's students in this period are second first-language learners. She explains, "this means the student either lost or is losing their first language and they are learning a new first language to replace it. The challenges they face learning literacy in English are even more significant than those of typical English Language Learners."

Table 1. A breakdown of the school day by period, subject, teacher, and the students in the classroom.

Period	Subject	Teacher	Students in the classroom	Student Demographics
1	Main Classroom	Samantha	5	2^{nd}-3^{rd} graders
2	Teacher Planning	Samantha	0	N/A
3	Braille Instruction	Allison	2	4^{th}-5^{th} graders
4	Lunch and Recess	Multiple	21	Elementary school
5	Main Classroom	Samantha	7	4^{th}-5^{th} graders
6	Literacy Class	Jackie	3	4^{th}-5^{th} graders, second first-language learners

3.2 Follow-up Interview and Design Activity

During our observation study, we discussed classroom technology and ideas for future educational technology with educators. After six weeks of our classroom observation, the school transferred to remote learning due to COVID-19. We conducted a follow-up interview over Zoom with the main classroom teacher and literacy teacher to gather their final thoughts. In the interview, we discussed how to design new tools based on classroom activities and how technology can adapt to remote learning. The final interviews were conducted individually with each educator.

3.3 Data Analysis

We audio and video recorded classroom activities, interviews with educators, and the final interview. We took field notes during all of the sessions and transcribed all audio and video data. We then discussed and analyzed the transcribed data and field notes using open coding techniques [17]. During open coding, we looked for themes surrounding (1) goals for students defined by educators, (2) instructional strategies, (3) technology in the classroom, and (4) supporting remote learning.

4 CLASSROOM OBSERVATION FINDINGS

This section characterizes typical classroom activities, physical artifacts around the school, and teaching philosophy. We also delve into instructor strategies used to teach academic and ECC skills. Finally, we present educators' perspectives on technology and how they use technology to supplement their teaching.

4.1 Classroom Structure

There are a small number of students in the class per period, so classrooms are structured to promote collaborative group activities. Classrooms typically have one or two round tables for students to sit together. Individual desks are for instructors and staff members.

The main classroom holds many resources for instruction and play. There are shelves against the wall with print books, Braille books, blocks, toys, and Braille typewriters. There is a large piano keyboard against the wall, with Braille labels on the keys and headphones to plug into the keyboard. The main classroom also has a sink and dish rack by the door for students to use when they eat or meal prep during class. There are bean bags in the corner of the room for students to sit on during reading time or if they are tired or unwell.

Literacy and Braille class have fewer objects in the classroom. Literacy class has a bookshelf that students use for individual reading time. There are comfortable armchairs in the corners of the room that students can lounge in while they read. Braille class almost exclusively has tools for reading and writing Braille. There is a shelf by the door that students select a Brailler from, along with paper and Braille erasers. All classes have suspended electrical sockets and chargers that educators can pull from the ceiling (Figure 1). The suspension prevents students from tripping on wires on the ground when they walk through the room.

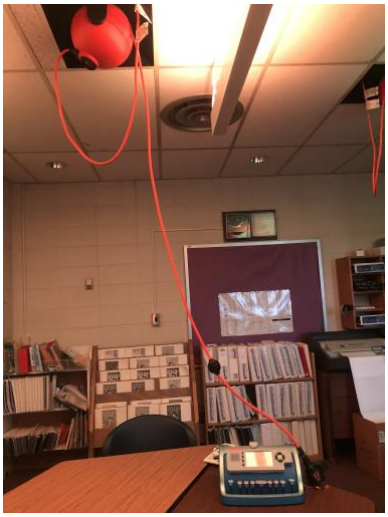

Figure 1. A Smart Brailler plugged into a suspended socket from the ceiling.

The school displays tangible artifacts all around the classrooms and hallways. Each classroom has Braille notation references and posters with Braille labels stapled to the walls. The cafeteria has a board with laminated labels of each student's name in print and Braille. Students find their name on the label by touch and put it on a particular side of the board to indicate if they are at recess or lunch. The library and hallways have tactile geographical maps for students to explore (Figure 2). Students feel the tactile maps in the hallway as they walk to their next class or play with them in the library before settling in for technology class.

Figure 2. A tactile map of the United States in the library. Students have placed plastic dinosaurs on the map to play with.

4.2 Teachers Setting Goals for Students

4.2.1 Behavioral Philosophy and Goals

In the main classroom, Samantha's primary goals for students are to build (1) independence, (2) communication skills, and (3) basic manners through collaboration. She reiterates that her goal is not to speed through the lesson plan for the day but enable students to be "as successful and independent as possible."

Educators emphasize these goals for students both in the classroom and during recreational times like lunch and recess. On occasion, educators interrupt their academic instruction to discuss communication techniques with students. For example, after recess one day, a student complained that another student had repeatedly bumped into them in the hallway. This incident sparked a class discussion about communication, personal space, and setting boundaries. Students practiced setting boundaries and adjusting the tone of their voice to sound more authoritative.

Educators at the school value choice and provide students with autonomy over their learning. Small classroom sizes enable students to have more power over their education, especially in their main elementary classroom. Samantha explains that one of her teaching philosophies is "let the students teach me what they need to learn." Lesson plans are flexible and often stem from students' suggestions or their questions from previous lessons. During class, a student asked Samantha, "what is a constellation?" This question prompted a new lesson plan for the next day: discuss outer space and stars and write a reflection on the discussion in Braille. Previous work, including formal theory, assessment on student autonomy, and case studies in the classroom, supports integrating autonomous learning into the curriculum [6].

4.2.2 Academic Goals: Literacy, Braille, and Reading Comprehension

In Braille and literacy class, educators value behavioral skills but center their goals on academic learning outcomes. Both of these subjects derive their lesson plans from the Wilson Reading System [57] and promote heavy use of Braille. We observed students working on letter recognition, phonetics, learning short words, and word contractions.

In the main classroom, Samantha's academic goals focus on reading comprehension. She begins class by reading the students a few chapters of a book. She then instructs students to reflect on what happened in the

book, how it relates to their own lives, and summarize the chapters. Students reflect on the readings both verbally and by writing in Braille with Braille typewriters.

Braille is used in all classes to build both academic skills and functional skills. It is even used in specialized subjects like music class and during lunch. Samantha explained that Braille is crucial for developing all aspects of literacy and preparing students to find employment. This belief aligns with previous research, such as Ryles (1999), that shows Braille literacy can improve employment chances and enhance literacy skills such as reading comprehension [43]. Educators explained that while visually impaired students may prefer auditory learning, the standard for literacy is still Braille competency. Jackie adds, “students cannot learn to spell unless they can see words, and they see words with their fingers. If students are only getting auditory input, we have found that their spelling is so poor that you can’t understand what they have written.”

4.3 Educator Strategies for Expanded Core Curriculum

In this section, we discuss how educators taught a few of the skills outlined by ECC.

4.3.1 Independence

Educators wove independent living skills into many classroom activities, particularly in the main classroom. When we began our study, students were in the middle of reading the children’s novel *Because of Winn Dixie* by Kate DiCamillo [20]. The class read a chapter in which characters ate egg salad sandwiches, so the lesson plan for the next day was making egg salad sandwiches (Figure 3). Students had to perform tasks independently, such as spreading mayonnaise onto bread and taking turns washing their utensils after eating. Samantha explained that “making yourself a sandwich and the concept of spreading can be challenging for kids that don’t have vision. As well as table manners, like waiting for somebody else.” After eating the sandwiches, one student exclaimed, “independence makes it delicious!” Educators used smaller tasks, like food preparation, to build more complex skills like patience and etiquette.

Figure 3. A student preparing an egg salad sandwich during class with bread, eggs, condiments, and spices.

Independence is also stressed during lunch and recess. Students are responsible for picking up their food in the cafeteria, putting away their trays after eating, and gathering their belongings before lining up for recess.

Students also attend an Independent Living Skills class a few times a week to develop this portion of ECC. This class follows a checklist of skills that students must master at each age (Appendix 1). This list covers a wide range of skills, including putting on clothing, identifying food items, and completing basic hygiene tasks. Each student is tracked on their progress using this checklist, even outside of the Independent Living Skills class. Middle school and high school students live in dormitories on campus to continue developing these skills.

4.3.2 Communication and Collaboration Skills

Educators encourage students to start class by communicating their emotions to their peers and see how their friends are doing. For example, when students go to music class, they start with a song to check in with each other's emotional states. First, a student will sing, "How are you [name of student next to them]? What's going well today?" The student next to them will respond in song. The whole class will validate how the student is doing by singing, "and that's okay!" in unison. Music is a popular tool for emotion regulation at all ages and can help process negative emotions and provide consolation [33,44,45].

Educators consider body language a strategy for effective communication and often remind students to be aware of their physical movements. For example, when one student asks another student a question, educators ask the students to turn their entire bodies to face each other as a sign of respect. In the morning, if a student is tired and lays their head down on their desk, educators ask them to lift their head to show that they are ready to learn. Some students have repeated fidgeting behavior, like rocking or bouncing. Educators use the phrase "still bodies" to remind students to be aware of their movements and minimize distracting their peers.

Most lesson plans incorporate collaborative activities involving all students in the room. When Samantha reads a book to the class, students ask each other to explain terms they do not know. During writing activities, students work together to figure out which cell numbers make a Braille letter. Students seem excited when they get the opportunity to teach concepts to their classmates. Educators remind students to consider the tone of their voice and word choice when collaborating and explaining concepts to their peers. These reminders reinforce manners and polite communication.

4.3.3 Literacy Skills

Literacy instruction includes Braille letter recognition, spatial awareness and orientation, contractions, punctuation, spelling, and reading comprehension. Jackie uses Magnetic Journals and flashcards to teach letter recognition and spelling three-letter words. Magnetic Journals are folders with a set of square Braille magnets. Each magnet has a print letter and a Braille label (Figure 4). Jackie tells students a three-letter word that she wants them to build using the Braille magnets. She uses phonetics as a clue for spelling by using prompts like, "what are the sounds you hear in the word 'map'?" Students then feel the Braille letter on the magnets and arrange the letters to create the prompted word. The Braille magnets have no tactile markers to orient the direction of the letter, so students often struggle to find the letter they need.

Students practice spelling in Braille class by playing a fill-in-the-blank game. First, students read a sentence with a missing word in Braille. Students pick between two options to fill in the missing word in the sentence. For example, students read, "An ape lives in the _____." Students filled in the blank by picking between the words "jongle" and "jungle". Students also practice short word contractions in Braille class by translating uncontracted Braille to contracted Braille.

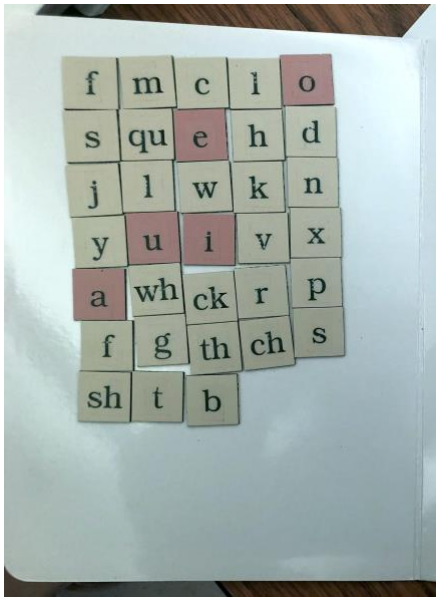

Figure 4. Magnet journals from literacy class. Each magnet has a print letter along with a Braille label on top.

In the main classroom, Samantha does not directly teach new Braille concepts. Students practice Braille through other academic and functional skill-building activities, including answering reading comprehension questions, brailling grocery lists, and reading instructions for different tools. Students also passively use Braille when they play with toys around the classroom during their free time.

In all classes, students with some vision have the option of reading and writing in print. These students can write by hand, use high contrast keyboards to type, and use magnifiers to read. Students with residual vision are still taught Braille, as they may have degenerative eyesight, but are not required to use it as frequently.

4.3.4 Rewarding Behavior

Students have leisure time called Choice at the end of each period. Choice is approximately the last 10 minutes of class during which students can partake in any activity they want in the classroom. Options include reading, iPad time, playing with blocks and toys (Figure 5), and the popular music station with a piano keyboard with Braille labels on each key (Figure 6).

Figure 5. Two students playing with blocks during Choice. The blocks have Braille, numbers, letters, math symbols, and animals on them.

Figure 6. A student playing the piano keyboard during Choice. Each key of the keyboard has a label with the print letter for the note along with the Braille letter.

Educators keep track of students' behavior through Levels (Figure 7) and Dojo points. Levels are tiers of student behavior that represent rule-following. Level 1 is where students start. Level 1 indicates that the student meets classroom expectations by being polite, completing activities productively, and displaying independence by trying things on their own or asking peers for help before an adult. When a student fails to meet classroom expectations, their behavior level increases, and they may lose Choice time at the end of class or miss recess.

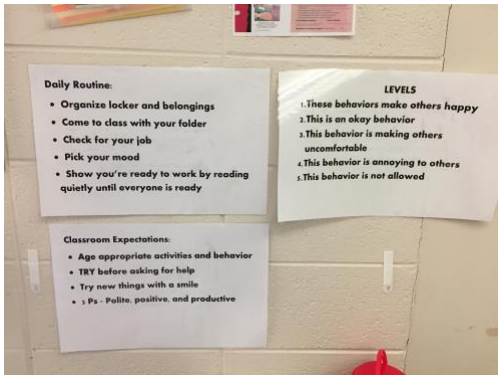

Figure 7. These classroom guidelines have Braille embossing on them so that students are reminded of behavioral expectations when they walk into Samantha's classroom each day.

Dojo points represent collegial behavior. Educators award points to students when they answer questions in class, help others, are responsible with their belongings, and follow instructions. Educators record Dojo points in a portal that parents can view. When students achieve a certain number of Dojo points, they receive rewards like extra Choice time or small tokens like hair scrunchies and miniature car toys.

4.4 Tools and Technology in the Classroom

4.4.1 Repurposing Tools for Instruction

Samantha and Jackie repurpose tools for their instruction as an alternative to using specialized technology for visually impaired children. They create Braille labels with a slate, stylus, and tape and attach them to blocks, magnets, flashcards, and musical instruments. Educators add Braille labels to adapt standard educational tools to meet the needs of visually impaired students, like the Magnetic Journals from the Wilson curriculum (Figure 4). Smaller tangibles with Braille labels are also convenient for students to pass around the table and share than larger devices like Braille typewriters. Jackie also used hula hoops and plastic mats to create enlarged Braille representations and help students with spatial awareness. However, these "did not translate" when students returned to the standard Braille cell. Other than the tangibles she has adapted, Jackie says, "we don't have any other cool things. I wish we did."

4.4.2 Technology in the Classroom

In addition to the computers and typewriters available to students, the school gives each student an iPad. Students receive training on how to use their iPads and voice-over software in their technology class. Samantha said that she occasionally builds lesson plans around academic applications on the students' iPads. Students also play with their iPad applications during instruction in math class. In the sessions we observed, students in the main classroom primarily used the Perkins and Smart Brailler during instruction. However, during Choice time at the end of class, students used their iPads to watch YouTube videos, played on the electronic keyboard, and practiced typing on the computer.

Jackie avoids using technology in her literacy class until students have mastered Braille reading and writing, typically occurring in middle school. "Blind people, in general, do not read at the same rate as their sighted

peers because it is a much lengthier process. That is another reason we back off on the auditory and focus more on Braille," she explains. The tools she builds encourage students to explore through touch and movement rather than rely on the audio output commonly found in assistive devices for visually impaired people.

By contrast, Allison frequently uses computing technology in Braille class. Students use iPads, refreshable Braille displays, and Smart Braillers for classroom activities and Braille assessment testing. Students connect their iPads to an Orbit Reader 20 [39] to type into the Notes application on their iPad when writing contractions or completing fill-in-the-blank activities. They also practice contractions with the Smart Brailler [50] (Figure 8). While waiting for Allison to set up devices, students occasionally played with the Taptilo [55], a smart toy that teaches Braille through music and word games.

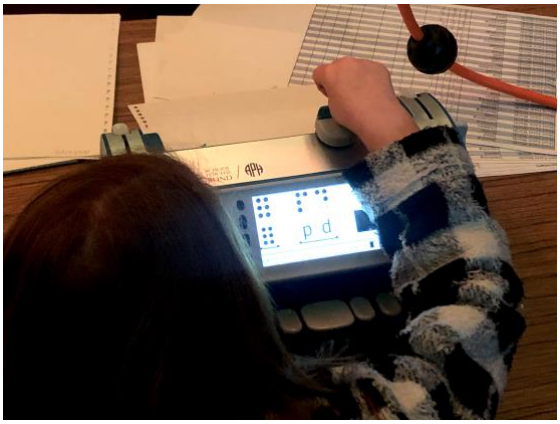

Figure 8. A student uses the Smart Brailler to practice letter contractions in Braille.

4.4.3 Educator Perspectives on Technology

Throughout the study, we discussed educators' perspectives on technology with them. Educators acknowledged that students are highly motivated by using technology, partly because their sighted friends and family members also engage with the same devices. Jackie explained, "my daughter is deaf and blind, but she will put on headphones, and she will take the phone and play with it like everyone else, even though there is nothing that she can access. But everyone else is doing it right?" Samantha adds, "students want to use those devices. That is one of the biggest benefits of them because it is not like pulling teeth[1] getting them to use it." She also appreciates that devices like iPads and phones can be more inconspicuous than bulkier tools like Braille typewriters. "It's a little more normal. I want them to be able to make the conscious decision of 'I want to use this thing, but it looks a little strange. Now I know how to use this thing that doesn't.'"

Educators also reflected on state-of-the-art and commercial technologies that are popular in the classroom. Samantha applauded the Perkins Brailler for reliability, saying that it was "always going to work." She elaborated that while children prefer to use Smart Braillers because of their engaging output and integration with technology, they can be problematic. Allison echoed this sentiment, explaining that with Smart Braillers, "the auditory feedback is really nice because you know right away what you Brailed. Older students who know Braille may

[1] The phrase "not like pulling teeth" in this context means that it is not difficult to motivate students to use technology.

not need auditory feedback, but they still think it is fun." However, Smart Braillers are loud, often do not load the paper correctly, and educators have to reboot them frequently. Loudness was a common issue with popular technology and software, including Jaws (a voice-over software), TypeAbility (a software program used to teach typing on a keyboard to students), and Braille printers. Students often complained that they could not hear the audio output on their device when the Braille printer in the library printed, or when too many other students were using voice-over without headphones.

5 FINAL EDUCATOR INTERVIEW

After the observation study, we conducted remote interviews with Samantha and Jackie, the main classroom teacher, and the literacy teacher. We presented educators with a few iPad game ideas based on activities we observed in the classroom (Appendix 2, Figure 10, Figure 11, Figure 12). With these game ideas as a reference, we asked educators to consider future technology features that better support instruction. At the time of the interview, the school had transferred to remote education due to COVID-19. We asked educators to reflect on the role of technology in online learning and what designers should consider when building technology for this context.

5.1 Design Considerations

5.1.1 Positive Auditory Reinforcement

Both Samantha and Jackie emphasized that new systems should focus on motivating students to learn and play consistently. Jackie explained that one way to do this is through audio feedback during play. "One thing that will happen in our student population is kids will get things wrong, and then they kind of give up…some praise would be really appropriate because that's really motivational."

Samantha added that systems should provide more audio when students get the correct answer and less when they get an incorrect answer. She explained that the Taptilo playfully teases students and provides exaggerated sound effects when students get an incorrect answer. The funny teasing makes students enjoy getting answers wrong while using it. "I think it would be great if we could find something that was super motivating so that they will want that much more than the wrong sound, like 'Great job you spelled the word cat woohoo!'"

Samantha and Jackie added that too much audio, like excessive voice-over, can be distracting for students. They recommended minimal motivational feedback so that educators and parents can provide more detailed information for students. Jackie also noted that voice-over software like JAWS is unreliable and hard to understand, so designers should build audio directly into the technology.

5.1.2 Tracking Progress

Tracking student learning history and progress is a priority for educators. Samantha elaborated, "I think it would be nice to get the completed list of how many [activities] students got done, what they spelled right, what they did. Just for data or 'oh he only wrote one word down during the 30-minute lesson, I might need to have a conversation.'" Jackie also recommended sending a progress report automatically to parents and educators. In the classroom, parents are kept up to date on student progress through a portal in which educators and parents

can directly communicate. Educators also host interventions with parents and students if students need extra support in specific skills or their parents require instructional training.

In remote education, students are taking a more active role in tracking their learning. Jackie explained that students complete a task on their own time, like tying their shoes, and then send a picture to their teachers as proof of completion. “One of the things that I am having students do right now is I give them an assignment to make a video. In that video, they have to tell me step by step what they are doing and what the end goal is. That actually helps set them up to be really good writers because they have to speak in an organized fashion.” Jackie calls this “task analysis” and says, “we break tasks down into small steps and make sure that students understand every single step because we cannot assume that they have the background knowledge.”

5.1.3 Teacher Control and Collaboration

During the uncertainty of remote teaching, educators expressed that they want more control and understanding over the content their students are engaging with. Samantha explained that in remote collaboration, it would be helpful for her to see what students see on their screens so she can help them troubleshoot any issues. “I would love to have a teacher view while students are going through games and see what they are creating.”

Jackie stressed that she “likes the idea of letting the students direct the learning” by letting students choose the activities and games they play. However, she wants educators to have the option of customizing activities to address skills that individual students need to work on. She also recommended adding a feature with which students could ask their educator questions through their devices. “One of the main ways that we really delve into what students are thinking is when we ask, ‘what questions do you have?’ That allows students to process what they have just been doing at a little bit of a deeper level.” In remote learning, educators may lose this ability to have students reflect on their academic content. Features that can mimic these in-person instructional strategies may help preserve some of the learning benefits that arise from collaboration and conversation during lessons.

6 DISCUSSION

From our study, we learned that educators integrate ECC skills like independence, responsibility, and communication skills, into academic lessons and emphasize them as core parts of classroom culture. Instruction in academic areas, like Braille, also simultaneously build ECC skills. In our interviews, educators emphasized that new classroom technology should include appropriate auditory feedback, progress tracking, and educator control, especially for systems that support both in-person and remote collaboration.

In this section, we reflect on our findings and how they relate to our initial research questions. We discuss designing new tools based on strategies we observed in the classroom and flexible design for independent and collaborative play.

6.1 Supporting Educators in Balancing Educational and Life Skills

Our findings aligned with related work showing that TVIs heavily integrate ECC education with academic instruction during the school day. From here, we reflect on how to use the classroom strategies we observed to design tools that leverage real-world skills to build academic skills.

6.1.1 Mirroring Educators' Instructional Strategies

Educators at the school used Braille to work on ECC components, like food preparation, so that students could strengthen both skills simultaneously. We can use this pattern of using Braille to combine academic curriculum with ECC to design tools that develop the multifaceted skills that educators prioritize. For example, one section of the Independent Living Skills checklist for elementary students at the school was "Laundry Skills." This section includes tasks like "putting clothes away with minimal assistance" and dressing oneself. Building these skills is an opportunity for household items to become tangibles that students can use while playing. A parent can give the student a basket of laundry. The student can pick up a clothing item, identify what it is, Braille the name of it, and show it to a laptop camera or phone camera to get audio feedback verifying if they are correct or not. This model allows students to develop literacy, build tactile skills, and play independently with the assistance of a camera and audio feedback.

A key instructional strategy we observed was the different methods of rewarding behavior and academic performance. Educators separated their classroom values by (1) personal behavior with Levels and (2) social etiquette with Dojo points, though the two-point systems had vague areas of overlap. Levels and Dojo points seem to reflect operant behavior theory by B.F. Skinner [49]. Skinner presented positive reinforcement (rewarding good behavior so that the subject repeats it) and negative reinforcement (the subject changes their behavior to avoid adverse stimulus). Levels seem to have a disciplinary structure: students start at Level 1, indicating that they are meeting the base classroom values. As the level increases, students may have activities or leisure time taken away from them. As their level goes down, students gain back the freedoms that they normally have. A higher level could be an adverse stimulus used for negative reinforcement in students. Dojo points have a reward structure closer to positive reinforcement. Students constantly work to get more points but don't fear that their actions will result in point deductions. Future technology can use multi-part reward systems to mirror the complex responsibilities students have in the classroom.

6.1.2 Designing Around Existing Technology

Our study found that students preferred to play with iPads and game-based toys with engaging audio, like the Taptilo. They used typewriters, Smart Braillers, and refreshable Braille devices during academic lessons and used tangibles, like blocks, for both work and play. This finding aligns with Samantha suggesting that students may gravitate towards "normal" and inconspicuous tools, like iPads and blocks, over larger devices like a typewriter. Previous work inside and outside the classroom reflects this preference for discrete technology. Shinohara and Wobbrock (2011) found that visually impaired people felt that technologies that were visible and "strange" looking attracted more attention than their mainstream-looking devices [48].

Branham and Kane (2015) found that assistive devices, such as screen readers, were disruptive and hard to share in collaborative work environments between visually impaired and sighted people [16]. This work, along with our findings, suggests that both the physicality and output modes of assistive tools may cause social discomfort. When designing new technology, we can explore integrating new applications with existing technology and building systems that mimic the commonalities between popular, mainstream devices: sleek, screen-based technology, and popular toys among all children, like blocks.

6.2 Building Instructional Tools with Flexible Interaction

An emerging theme in our work was that educators wanted new systems to be flexible and support independent and collaborative play. However, independence and collaboration may take on different forms as remote learning becomes a norm for students. Here we explore what features can support parents, educators, and students in different contexts for learning and play.

6.2.1 Independent Play and Interdependent Collaboration

Playing alone builds independent living skills in students and alleviates some of the responsibility placed on parents and other caretakers. However, even when students play and learn independently, they still have relationships with their parents and educators that affect their interaction with assistive technology [5]. For example, during remote learning, parents have been placed in charge of their child's education. Parents who work during the school day may want to monitor their child's learning at the end of the day or send progress reports to their teacher. Jackie explained that educational games with progress tracking are valuable in this situation because the child can play independently, "but the teacher can still get feedback without it having to be something that the parents are super involved with." With remote education becoming a long-term possibility, we can support students using technology independently while still considering this interdependence framework [5]. This support could look like developing features such as asynchronous guidance from parents or educators via detailed audio instruction or automated progress reports sent to parents and educators.

6.2.2 Designing for an Unpredictable Mixture of Classroom and Remote Learning

During remote education, parents have become the primary educators in areas they may not have background knowledge. Even during in-person instruction, parents are encouraged to read aloud and learn with their children at home to create "active experiences" that help them explore early literacy [18]. In future tools, we can facilitate shared learning experiences by including resources for sighted collaborators to learn alongside visually impaired students. We can do this by building multi-player systems for games or simple solutions like providing templates that map Braille notation to print letters.

In our findings, we discussed remote collaboration between students and educators. However, another crucial dynamic in classrooms is peer-to-peer interaction, which students have lost during online education. We can develop peer collaboration features based on how students interact in person. As we discussed in section 4.1, students often sit in one large group, take turns answering questions, and are encouraged to ask each other for help. Designers can consider features that allow students to play synchronously, with scheduled game times. We can also consider ways for students to ask each other for help, like a "phone a friend" option. Systems can simulate classroom interactions so that students do not feel further isolated during remote learning and can continue building their social and behavioral skills.

7 LIMITATIONS AND FUTURE WORK

Our observation study and interviews enabled us to understand the academic and behavioral goals that TVIs prioritize for their students. We also learned how educators currently use technology and how future technology can support instruction for a wide variety of skills. In this section, we discuss the limitations of our work and how they can inform future research.

The scope of this work focused on the perspectives of educators in the classroom. However, students, parents, and administration play a crucial part in the dynamic we observed. We chose to center our narrative on one of these groups to provide a detailed view through the educator lens. However, this is a limitation of our work. Future work can observe and interview visually impaired students and their parents about how they use technology like assistive devices and games. Additionally, researchers can work with school administration to understand how technology fits into the instructional philosophy created by Principals, superintendents, and staff.

A challenge we faced is observing a classroom that integrates academic instruction with the Expanded Core Curriculum. This instruction blends several behavioral and academic skills and is subject to change depending on how students behave that day or what questions they ask. Future work can delve into how educators dynamically adapt lesson plans on the spot based on how peers interact with each other and the signals that cause deviation from the original lesson plan.

In future work, we are interested in co-designing educational game systems with educators and students based on the guidelines we learned through this study. We began this work during this study by discussing potential game ideas based on classroom activities with educators. By continuing to design with educators, we can gain their unique perspective on how to map games to grade/age-specific content, what collaborative features would help educators and parents support students, and what reward strategies encourage students to play and learn consistently.

Along with the design, we need to test these systems in diverse contexts to understand how students collaborate, play, and learn. Educators remarked that educational games are played independently and with families at home, in the classroom during free play, and integrated with academic lessons during instruction time. However, they explained that certain elements that work in classrooms might not work at home. For example, tangible toys might work for systems that are meant for organized classrooms but could get easily lost at home. We will further study how to build systems that can adapt to different learning and play contexts for students and their collaborators.

8 CONCLUSION

Teachers of the Visually Impaired require instructional tools that align with their academic, behavioral, and functional goals for students. This work studies how technology can support teaching multifaceted skills to students who are blind or visually impaired. It also explores how to develop systems that foster both remote and in-person collaboration between students and their educators, peers, and family members. Our study shows that by working with and observing educators and students, we can understand strategies that motivate students to learn literacy and behavioral skills crucial for their ability to live independently.

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A APPENDICES

Appendix 1 Independent Living Skills Checklist Sample

Please Select Category

- Advanced
- Dressing Level 1
- Dressing Level 2
- Food Management Level 1
- Food Management Level 2
- Not Counted
- Personal Hygiene
- (blank)

Please fill in all fields with :
0 - Not yet proficient
1 - Proficient
x - skill does not apply due one of the following attributes:
(F) - Applicable to female students only
(M) - Applicable to male students only
(O) - Optional skill, depending on student use

Category	Skill	LL	UL	Age Range	Pre	Mid Year	Post
Personal Hygiene	Bathing (washing body)	4	7	4-7			
Personal Hygiene	Blow and wipe nose	4	7	4-7			
Personal Hygiene	Brush teeth	4	7	4-7			
Personal Hygiene	Cover nose/mouth when sneezing	4	7	4-7			
Personal Hygiene	Demonstrate proper hygiene when toileting	4	7	4-7			
Personal Hygiene	Dry hair with hair dryer	4	7	4-7			
Personal Hygiene	Dry own body and towel dry hair after bath	4	7	4-7			
Personal Hygiene	Ensure privacy when bathing or toileting	4	7	4-7			
Personal Hygiene	Operate paper towel dispensers and air hand dryers	4	7	4-7			
Personal Hygiene	Participate in several parts of the bathing routine	4	7	4-7			
Personal Hygiene	Perform routine hygiene activities at the appropriate times	4	7	4-7			
Personal Hygiene	Shampoo hair and rinse	4	7	4-7			
Personal Hygiene	Use a brush, comb or pick for styling own hair	4	7	4-7			
Personal Hygiene	Use a variety of sinks and showers	4	7	4-7			
Personal Hygiene	Wash and dry hands at appropriate times	4	7	4-7			
Personal Hygiene	Wash face	4	7	4-7			
Personal Hygiene	Apply deodorant	8	11	8-11			
Personal Hygiene	Care for dry or oily skin and dry lips	8	11	8-11			
Personal Hygiene	Care for nails	8	11	8-11			
Personal Hygiene	Clean and care for eye prosthesis, contact lenses or glasses, hearing aids or devices. (O)	8	11	8-11			
Personal Hygiene	Use dental floss or flossing tool	8	11	8-11			
Personal Hygiene	Identify when a haircut is needed and perform necessary steps to obtain one	12	15	12-15			
Personal Hygiene	Knowledge of popular hair styles and communicate a desired cut to the hairdresser	12	15	12-15			
Personal Hygiene	Purchase or obtain grooming supplies and items for personal hygiene	12	15	12-15			
Personal Hygiene	Shave underarms and legs/Shave or maintain facial hair	12	15	12-15			
Personal Hygiene	Use appropriate amounts of cosmetic lotions, creams, perfume, or cologne.	12	15	12-15			
Personal Hygiene	Use hairstyling products or techniques to maintain a hairstyle	12	15	12-15			

Figure 9. An Independent Living Skills checklist used at the school we observed. The school adapted this checklist from checklists at the Texas School for the Blind and Visually Impaired.

Appendix 2 Game Ideas and User Interface Design Mock-ups

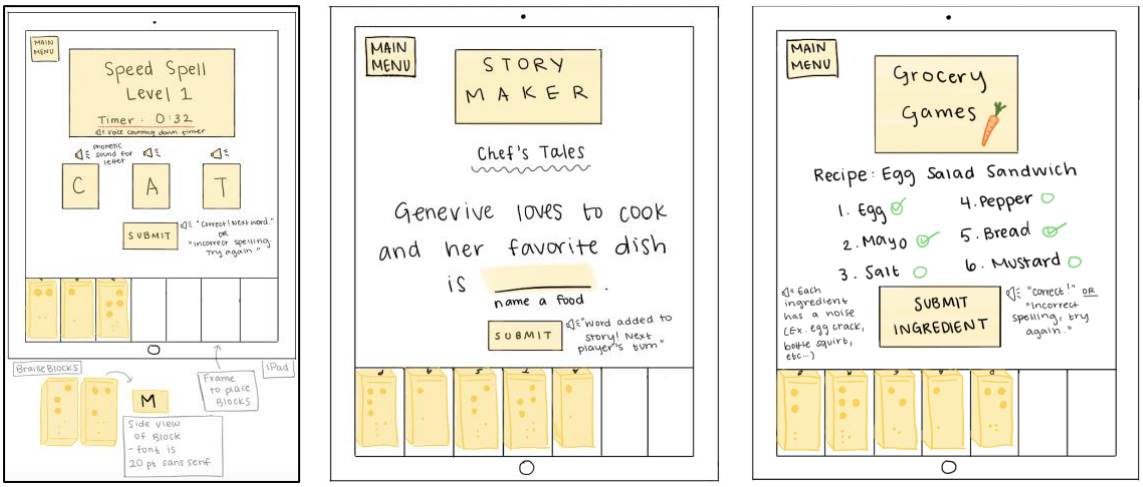

Figure 10 (left). Speed Spell is derived from the Magnetic Journals used in literacy class to learn words in the Wilson Reading System. Students can choose from five levels of difficulty. Each level corresponds to a new learning goal from the Wilson curriculum. Figure 11 (middle). Story Maker is a collaborative game inspired by students building stories together in literacy class and fill-in-the-blank games used to practice spelling in Braille class. Students, or an educator, can select a story theme for students to fill in. In our UI mockups, we presented two story themes: Chef's Tales and Magician Adventure. Every few sentences of the story have a blank where a word should be. Each blank has a prompt for the kind of word a

student should add. Figure 12. Grocery Games is inspired by the food-related activities from the main classroom, such as making peanut butter sandwiches and brailling ingredient lists for different recipes. Students first choose a recipe like “Egg Salad Sandwiches” or “Carrot Cake”. They then guess the ingredients that go into the recipe and write the grocery list using the blocks.