Supporting Behavior Management with a Classroom Display Providing Immediate Feedback to Students

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ABSTRACT

Managing behaviors in classroom settings requires clear communication of expectations, and consistent feedback to students about whether the expectations are being met. The literature indicates a significant gap between evidence-based strategies for behavior management and implementation of these strategies in real classroom settings. To address this gap, we engaged school practitioners in examining and designing for the implementation challenges they face. This work focused on one of the most common classroom behavior management strategies, the token economy, and how it is utilized across special education and regular education settings. Using the approaches of action research and human-centered design, we explored the integration of pervasive computing technologies in classroom practices to address key implementation challenges. We present a resulting prototype that we developed and deployed, a classroom display, and describe its integration into the classroom flow. We discuss findings about the role pervasive computing can play in supplementing existing classroom behavior management practices to help students be aware of their behaviors throughout the school day.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in ubiquitous and mobile computing**.

KEYWORDS

Behavior management; special education; classroom display; human-centered design; action research.

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1 INTRODUCTION

Behavior management is a critical component of any classroom. Managing behavior involves defining clear expectations and rules, providing specific feedback, and continuously adapting responses to behaviors of individual students [38]. School practitioners across special education and regular education settings draw from the same behavior management strategies informed by decades of evidence from behavioral psychology research [38]. Behavior management from an early age reduces problem behaviors, increases desired on-task and social behavior, and improves long-term outcomes for young adults [20, 36, 38].

However, there are challenges for implementing behavior management strategies with high fidelity in order to be effective. Fidelity is a measure of the degree to which implementation is comprehensive and consistent [5]. Some estimates indicate that at least 80% fidelity is required to produce intended results of a behavior management program [18]. Implementation fidelity can be increased through training [4] and consultation from school psychologists [31], but these approaches are resource intensive. Once achieved, high implementation fidelity is also difficult to sustain [36]. To examine challenges with implementation, we focus on the token economy, because it is one of the most common and well-known strategies for behavior management across special education and regular education classrooms.

1.1 The Token Economy

The token economy is one of the oldest, most widely applied, and most extensively studied methods of behavior management in institutional settings [1, 19]. A token refers to a tangible or symbolic item (*e.g.*, sticker, point) that is given to reinforce desired behavior. Tokens are collected over a period of time and then exchanged for a reward—a secondary reinforcer chosen by the individual, which holds a designated value so that it motivates sustained behavior (*e.g.*, toy, activity). The efficacy of this approach is derived from a combination of the immediate reinforcer of the token given for an instance a predetermined behavior, and the secondary reinforcer from the sustained effort of working toward a meaningful reward. For example, at the end of the school day, a student exchanges the 32 tokens she has earned for her behavior to play her favorite computer game for 5 minutes.

In use since the 1960s, token economies have undergone extensive investigation within special and regular education. In a review of evidence-based practices for classroom management, token economies were found to have broad effects, including increased positive and decreased negative verbal interactions, decreased transition time between activities, peer social acceptance, decreased talk-outs and out-of-seat behavior, and increased student preparedness for class and assignment completion [35]. In special education, token economies have demonstrated effectiveness in improving behaviors of students with behavioral disorders [33], autism spectrum disorders [24, 37], and intellectual disability [29]. Examples

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of studies in regular education include reducing disruptive behavior in a preschool classroom [13], improving student conduct in a fifth-grade classroom [2], and maintaining decreased inappropriate behavior in a ninth-grade classroom [23].

Despite the widespread use of token economies in classrooms, a significant rate of children with behavior problems continues to persist, with estimates ranging between 2 to 17% [9]. This disconnect suggests challenges in achieving and maintaining high implementation fidelity—for example, systematic reviews continue to highlight how difficult it is to maintain consistency [22]. School practitioners also do not have enough tools and support for implementing token economies [27]. More research has been recommended to identify supports that can help school practitioners ensure high fidelity of implementation with token economies [9]. There is also evidence to support the idea of supplementing and combining behavior management strategies. One systematic review found that token economies are more effective when not implemented on their own, but combined with other classroom management strategies, such as social skills training, peer-monitoring, and self-management [35].

1.2 Real-World Implementation Challenges

Effective implementation of token economies and other behavior management strategies requires monitoring behaviors in a way that helps students and the practitioners around them to communicate clearly about desired and undesired behaviors. Quantifying behaviors and recording instances enables students and practitioners to be mutually aware of behavioral expectations, goals, and progress. For example, a student might be awarded a point for quietly focusing on her work, sitting in her seat, raising her hand, or helping another student. The more children are aware of points they are earning, and for which behaviors, the more they learn about appropriate classroom behavior and become motivated to exhibit it. However, classroom settings require managing a range of behaviors at the same time, making it challenging to provide consistent feedback to every instance of a behavior.

Metzler and colleagues [30] found five features that are most important for behavior management to be effective, all of which require practitioners to help students with awareness of their behavior: (1) increasing positive reinforcers for appropriate social behavior, (2) active teaching of appropriate social behavior, (3) clear communication of a small number of rules, (4) consistent provision of corrective consequences for rule violation, and (5) ongoing monitoring of behavior to provide feedback on progress. We studied these features to understand the challenges of implementing them in the classroom, and identify the role that pervasive computing could play in supporting mutual awareness between students and practitioners. Our work draws from both school psychology literature indicating the need for tools and supports that can help improve implementation fidelity, and applications of pervasive computing in classroom and therapeutic settings.

2 RELATED WORK

By addressing the challenges of classroom-based behavior management, this paper complements research that has focused on behavior management at home [25], in individual therapy sessions [21], and other non-classroom contexts. Studies of pervasive computing integrated in classroom settings to support behavior management have shown feasibility, acceptability, and efficacy across special education [17, 28] and regular education [8].

One gap we identified in the literature is that the majority of these tools address the needs of practitioners and caregivers as they monitor and manage behaviors. For example, studies have supported the decision-making processes of educators, clinicians, paraprofessionals, and parents around behavior management [15, 26]. We build on these studies by examining classroom dynamics with a focus on how students form an awareness of behavior expectations, and their individual feedback and progress. For example, Marcu *et al.*'s study of behavior monitoring practices in special education [27] found that practitioners were innovative in visually representing a token economy for their students—for example with a display of pipe cleaners representing the number of tokens each student in the class had earned that day. These practices suggest an opportunity to enhance visual representations of token economies with pervasive computing, engaging students in understanding their behaviors and supporting practitioners to provide more consistent feedback.

vSked is a pervasive computing system designed in part to support a token economy [17]. Combining a classroom touchscreen display for the teacher's use with a mobile touchscreen device for each student, *vSked* was designed for facilitation and monitoring of task performance while providing students with a visual reference of the reward they were working toward. Similarly, Matic et al. [28] developed a digital classroom display to enhance a school's use of a token economy system. At the end of each school day, the display uncovered a cooperative puzzle, with each piece corresponding to a student. Each student's behaviors affected the degree to which their puzzle piece was revealed. Their study showed that visual reinforcers of behavior were a useful supplement to standard practice. Along with other studies [8], they also showed the importance of integrating the display into classroom structure, flow, and practices.

Building on these studies, we contribute an investigation of designing and integrating pervasive computing applications for children to reflect on their behaviors throughout the school day. Pervasive computing has been used effectively for interactive visual supports that are easier for practitioners to manage and update, and more informative for students, than traditional paper-based tools [16]. Pervasive computing technologies designed for children with behavioral needs have largely been educational games and therapeutic interventions [3, 6, 32, 34]. Despite the myriad pervasive computing applications for adults classified as self-assessment, self-tracking, quantified self, and personal informatics tools, there has been less design work focused on increasing self-awareness of children. We focus on how student and teacher behaviors are intertwined [12], which requires an understanding of classroom dynamics.

We also draw from school psychology literature at the intersection between special education and regular education settings. Students with behavioral needs can be placed in self-contained special education classrooms, or inclusive classrooms where they are integrated in a regular education setting for support. Students may also have additional support from specialists in their school's resource room, or consulting school psychologists or behavior analysts that serve their school district. More inclusive placement

is generally viewed as beneficial to a student's development. It is also true that special needs students *"in inclusive classrooms may not receive the immediate feedback from a teacher who is trying to provide feedback for all students in a class"* but *"assistive technology can provide immediate and continual feedback students desire"* [10]. To address this need across a variety of classroom settings, our work focuses on the challenges of conceptualizing an appropriate design that would fit classroom flow and meet the needs of students as well as practitioners.

3 METHODS

Our research was conducted using two overlapping processes, illustrated in Figure 1. First, we engaged practitioners from special education and regular education classrooms in action research over the course of about two years. As design opportunities emerged during this process, we began human-centered design, performing iterative prototyping together with the same practitioners. This design process enabled us to explore concrete design concepts and resulted in a prototype display application, which we implemented and evaluated in one of the classrooms.

3.1 Field Sites

Table 1 outlines the classroom contexts in which we studied behavior management. This study took place in a suburban area in the eastern United States, with a population across lower to middle socioeconomic status. All of the classrooms involved were located in the same school district, enabling us to understand how various stakeholders influenced decision making and implementation of behavior management. In addition to the classroom staff (teachers and paraprofessionals) working directly with the children, we engaged with building-level and district-level stakeholders who were involved in behavior management. School psychologists and consulting behavior analysts worked across the district, engaging more closely with individual cases based on need. For example, they would visit a classroom and interact with a student when a teacher or other school staff indicated behavioral challenges or requested a consultation. A classroom visit would include direct observation of a student's behavior, and advising on how to implement behavior management strategies.

Three of the classrooms (A, B, and C) were self-contained special education classrooms. A and B were next door to one another in an elementary school and were comprised of children in grades K-5. Together with a social worker across the hall who served as supervisor, these three classrooms comprised the school's behavior disorder program. Classroom C was the local middle school's behavior disorder program, grades 6-8, which was overseen by its own program director. These classrooms each had 12 students. One teacher was responsible for designating daily schedules and preparing activities, and two paraprofessionals provided daily support with academic work, behavior management, and data collection.

Children are recommended for placement in a behavior disorder program like the one we studied if they are too disruptive or unfocused to participate in a regular classroom. Often, children will reach a certain level of disciplinary action for aggressive or inappropriate behavior before this placement is recommended. For example, children with oppositional defiant disorder or conduct disorder may refuse to sit down and do the work that is assigned to them; children with attention deficit disorder or attention-deficit hyperactivity disorder may get out of their seat and distract other students instead of completing their own work; and children with anxiety disorders or psychological trauma may rip up their work or have trouble positively interacting with others.

Table 1: Summary of field sites, participants, and data collection methods. Classrooms represented both special (sped) and regular (reg) education.

Classroom	Students	Practitioners	Methods
A (sped) B (sped)	n = 12 Grades K-3 n =12 Grades 3-5	n = 14 (teachers, paraprofessionals, school psychologist, social worker, consulting behavior analysts)	Observation 250 hrs Interviews n=12 Focus Groups n=20
C (sped)	n = 12 Grades 6-8	n= 4 (teacher, paraprofessionals, program director)	Observation 5 hrs Interviews n = 3 Focus groups n = 2
D (reg)	n = 19 Grade 1	n = 2 (teacher, consulting behavior analyst)	Observation 10 hrs Interviews n = 5 Focus groups n = 3
Total	n = 55 Grades K-8	n = 20	Observation 265 hrs Interviews n = 20 Focus groups n = 25

Classroom D was a first grade regular education class, comprised of 19 students and one teacher, Mr. Newman. In practice, however, this classroom was not typical of regular education placement. Mr. Newman had shown an aptitude for working with children who exhibited disruptive behaviors. As a result, children tended to be in his classroom if they were close to placement in the behavior disorder program. Mr. Newman managed a full classroom of 19 students, some of whom had behavioral needs, without the support of any paraprofessionals. This classroom was therefore an informative context for our study, representing somewhat of a bridge between special and regular education.

3.2 Action Research

Action research is an interdisciplinary process of inquiry conducted by and for those taking the action. The primary reason for engaging in action research is to assist the "actor" in improving and refining his or her actions. Action research has been used in human-computer interaction to address human issues through computing

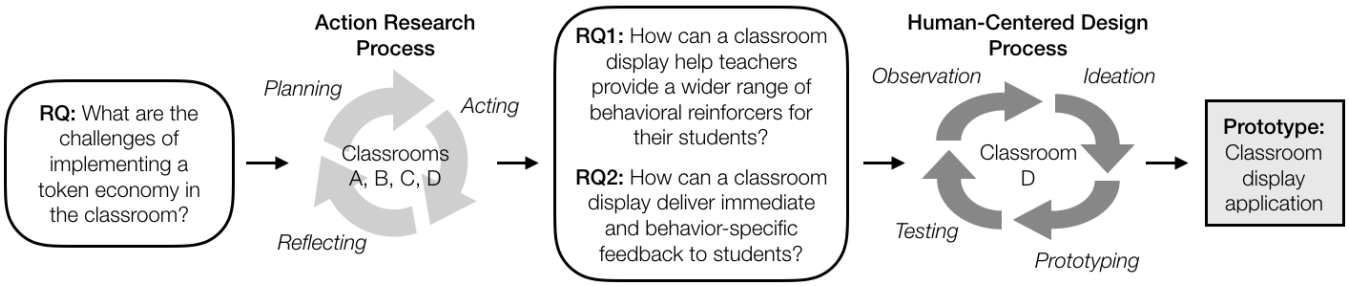

Figure 1: Methods

solutions [14]. The actors we engaged in this study are the 20 practitioners shown in Table 1, who worked across four classrooms as teachers, paraprofessionals, social workers, school psychologists. During 30 months of fieldwork, we spent over 265 hours conducting naturalistic observation, interviews and focus groups with these practitioners to explore the challenges they face in implementing behavior management strategies. The following activities were performed as part of the three iterative stages of action research, which are illustrated on the left side of Figure 1:

- Planning: We conducted a preliminary diagnosis (e.g., contextual inquiry), data gathering (e.g., observation and semi-structured interviews), and joint action planning to understand existing practices and challenges with implementing the token economy. During the deployment, we identified how we could iterate on the design to improve its fit into classroom flow.
- Acting: As actionable design opportunities arose, we began ideation and prototyping in response to needs we discussed together. Over time, these design activities culminated in a classroom display application, which we deployed and iterated on within one classroom (D).
- Reflecting: During iterative prototyping, we elicited input from multiple stakeholders by discussing to what extent the prototype would meet the needs of both practitioners and students. We paid particular attention to affecting practitioner workflow, student behaviors, and overall classroom dynamics. Together we then examined adoption of the prototype, and how it fit into classroom flow.

An emergent theme of our work together was the challenge of representing behavioral goals and progress to be able to communicate feedback clearly to children. This challenge became the focus of our human-centered design activities, through which we narrowed down concepts to a classroom display.

3.3 Human-Centered Design

A human-centered design process enabled us to explore emergent design opportunities in depth. Needs and opportunities we identified throughout the action research process informed our design work. This iterative process is illustrated on the right side of Figure 1. Based on the challenges we identified during classroom observation and preliminary diagnosis, we engaged practitioners in ideation of potential solutions. We prototyped these ideas, from low fidelity gradually to high fidelity, informally testing various concepts with other practitioners to obtain input from a range of perspectives.

We eventually narrowed down a variety of ideas to one concept that was most promising and feasible to practitioners, a classroom display. Together with the practitioners, we determined that classroom D was the best fit for a deployment of our functional prototype, based on the classroom dynamics and the teacher's past experiences using technology. The rest of our human-centered design process then focused the needs and constraints of classroom D.

4 FINDINGS FROM ACTION RESEARCH

As we came to understand how practitioners worked to help students be aware of their behaviors, we identified challenges related to each of Metzler er al.'s five features of an effective token economy:

(1) ***Increasing positive reinforcers for appropriate social behavior.*** Inappropriate behaviors tended to occupy practitioners' time because they needed immediate correction; as a result, appropriate behavior frequently went unacknowledged. Practitioners only visibly recorded student's desired behavior by placing a check-marks on an index card located on the corner of students' desks, and this did action not include verbal feedback.
(2) ***Active teaching of appropriate social behavior.*** Interactions with practitioners and peers were most important for learning appropriate social behavior; opportunities for these interactions were reduced after a serious behavioral incident due to required paperwork and coordination with other practitioners. Practitioners frequently left the classroom to manage incidents occurring outside the room, to remove a student, or to fill out paperwork for a prior incident. As a result, little time was left for teaching appropriate social behavior.
(3) ***Clear communication of a small number of rules.*** Students generally understood the rules, but were not always able to connect them to an awareness of their own behaviors. Practitioners struggled to provide enough individual feedback for students to connect a token to the behavior for which it was earned. They would also hear from parents that their children did not understand how exactly they had earned or lost their points.
(4) ***Consistent provision of corrective consequences for rule violation.*** A lower student to practitioner ratio helped with

responding to behaviors, but required additional coordination to maintain consistency. Corrective consequences were not used consistently, for example the same rule was violated by two students who were teasing in difference instances—one student was sent to the office, while the other was put in an isolated area called the 'cool-down room'.

(5) ***Ongoing monitoring of data on student behavior to provide feedback on progress.*** Practitioners monitored behaviors for their own awareness, while students frequently requested updates on their tokens earned. Feedback was primarily given verbally, which is demanding on practitioners' time and focus, and was therefore difficult for them to keep up with.

As we began to ideate and searched for the most actionable design opportunities, we learned that classroom D's teacher, Mr. Newman[1], had incorporated use of *ClassDojo* (a popular educational technology product[2]) to display his classroom's token economy during the previous school year. Although he appreciated having a way to display students' behaviors visually, his use of *ClassDojo* did not enable him to provide behavior-specific feedback to individual students throughout the day. Mr. Newman wanted students to have this information continuously available throughout the day, but with *ClassDojo*'s display feature had only been able to do this periodically. He was also not able to customize *ClassDojo* to his behavior management plan, because its functionality provided a limited set of options that he was not able to appropriate for displaying the information as he wanted.

A behavior analyst consulting in his school district also recognized the potential of a tool like *ClassDojo*, but when she had seen Mr. Newman use it in the past, she did not notice any effects on the students. She suggested the need for a customizable pervasive technology to aid with improving student behavior awareness. Such a tool would be useful if it could fit alongside existing practices by promoting structure within the classroom, so that students could receive more frequent behavioral feedback, whether from the practitioner or the technology.

The behavior analyst also gave us her point of view on the behavior profiles across students in classroom D. For example, she explained that half of the students were engaging in behaviors that made teaching challenging. These behaviors included attention seeking, and finding ways to get attention from the teacher in any way that they could. This situation would result in students not sitting in their chairs, and not listening to activities or instructions. Her assessment suggested that we were designing for a fairly unstructured environment, where implementing a pervasive technology for supporting student awareness could potentially add structure, but also risk unintended consequences of further destabilizing classroom dynamics.

The other practitioners in our study also agreed that a classroom display could be used for supporting student awareness of their behaviors, by providing easily accessible feedback to all students at the same time. We leveraged practitioners' experiences in implementing other tools, such as *ClassDojo*, to understand their limitations and elicit requirements for our display prototype. Below we describe how our findings of challenges led to two research questions we could address through design.

[1]All names are pseudonyms.
[2]https://www.classdojo.com/

4.1 Design Opportunities

One of the biggest challenges of implementing a token economy was providing rewards that were coveted and motivating for all students, but inexpensive and easy to keep a constant supply of. Candy, toys, and privileges were commonly offered as rewards, but these rewards were not always effective. For example, in classroom D, the teacher would give out candy at the end of each day, if time permitted. Each student was awarded one piece of candy for every token they earned that day, and this was the most consistent form of reinforcers provided. However, the students did not always want the candy, and some students were not able to eat them due to allergies. These observations led us to **RQ1: How can a classroom display help teachers provide a wider range of behavioral reinforcers for their students?**

Providing immediate and specific feedback is a common barrier to achieving the application of an effective token economy [30]. As we observed practitioners logging tokens to monitor progress toward rewards, we recognized the implications of the fact that little to none of this process was designed to actively help students be aware of their tokens. Students in all of the classrooms were continually inquiring about the number of tokens they had earned. For example, a teacher would call on a student with a raised hand, only to find that the question was not about the lesson but rather an attempt to check on their token status. Students in classroom A would draw charts on their desks to track progress to a reward on their own. Classroom D's teacher reported that he was unable to deliver feedback that was immediate and specific enough for a student to connect a token to the behavior for which he had earned it. These needs led us to **RQ2: How can a classroom display deliver immediate and behavior-specific feedback to students?**

Using the action research findings, we performed an iterative human-centered design process with a focus on the practitioners' needs, and informed by what we learned about behavior management across a range of classrooms through action research (Figure 1). We co-designed, deployed, and iterated on a classroom display application, with a focus on integrating it into existing classroom practices, and reducing the likelihood of unintended effects such as causing distractions or burdening practitioners with additional work. Our iterative human-centered design process resulted in a prototype of a classroom display, which we deployed in one classroom for a full school year (10 months). In the following section, we describe the design of the prototype.

5 CLASSROOM DISPLAY PROTOTYPE

The prototype is a wall-mounted classroom display that enables all students in the classroom to continuously check in with their behaviors throughout the school day. As a practitioner uses a data collection tool for logging tokens, the display pulls that data in real-time to generate a visualization for the students. For example, every time a student receives a token, two types of immediate reinforcers are delivered: a pleasant splash sound, and a pop-up graphic containing the student's name and the behavior category

in which they earned the token. The classroom display application aims to help students connect a reinforcer to the behavior it is meant to reinforce, through immediate and behavior-specific feedback—provided automatically, without additional work from the practitioner. Next, we describe the characteristics of the classroom display application and how each design decision was made to address the design opportunities we identified during the action research phase.

5.1 Helping Teachers Provide a Range of Behavioral Reinforcers

In this section, we describe which characteristics were incorporated into the classroom display application to support teachers proving a range of behavioral reinforcers to students. ***Token economy.*** The classroom display application is based on the token economies implemented in the classrooms we observed. The practitioner uses a data collection tool to collect students' tokens. Students receive tokens for positive behavior in four behavioral categories: be helpful, be responsible, be respectful, and be safe. Students can receive tokens at any time throughout the day, but after each period, each student's performance and behavior is evaluated for that block of time, and they are given an 'overall' token if they follow all of the behavior rules. The display also keeps track of how many warnings and reminders a student receives that day. Reminders are slight behavior corrections that a student receives, while warnings are more serious offenses, usually given out after a reminder if the behavior is not corrected.

Rewards Menu. As part of our solution, a rewards menu (Figure 2, left) was printed on a paper poster and hung next to the display, helping practitioners offer a wider range of rewards, and communicate to students clearly how many tokens could be exchanged for each of them. The prominent placement of the reinforcers menu next to the display showing real-time tokens status served to motivate students by reminding them the value of their tokens, and that their efforts to manage their behavior would be rewarded. At the end of each school day, the students exchange their tokens for their chosen reward(s), and the display automatically resets to track the next day's tokens.

Customization. One of the novel features of classroom display application, in contrast to available systems such as *ClassDojo*, is the ability to customize behavior monitoring for each student. Through a customization module, practitioners can enter any behavior to be monitored for each student. Instead of applying classroom-wide behavioral expectations, monitoring unique behaviors for each student results in tokens serving as reinforcers that are more specific and helpful to students. In addition, as students make progress, monitoring can be updated to reflect new goals. For example, one student could have trouble with social interactions so that each positive interaction can be counted and reinforced.

5.2 Providing Students with Immediate and Specific Feedback

The classroom display application has the following characteristics to provide students with immediate and specific feedback.

Visual feedback. The prototype is designed as a glanceable display [7], making it easy for students to quickly look up at the classroom wall to check on their tokens without having to decode a chart or graph. Each student in the class is represented by a frog sitting on a lily pad (Figure 2, right). A student's lily pad shows three numbers: number of tokens they have earned (above their name), reminders (in blue), and warnings (in red). Initially, we tried to facilitate only positive reinforcers through the classroom display application, which significant evidence suggests is most effective for behavior management. In reality, we found that all four classrooms we studied used some form of punishment-based reinforcers, such as the reminders and warnings. In collaboration with the consulting behavior analyst, we devised a system whereby disruptive or undesired behavior would result in a warning, which placed students on a 'time-out' making them temporarily ineligible to earn tokens. This compromise enables practitioners to be able to still enforce consequences without using punishment-based reinforcers.

Auditory Feedback. Audio alerts are another element helping to provide students with feedback on their specific behaviors as soon as the practitioner has entered a token. The audio for this display application was based on the audio alerts Mr. Newman had previously used with *ClassDojo*, and had been useful and liked by both him and his students.

A sound is played when students receive a token for positive behavior, or when they receive a warning or reminder for demonstrating undesirable classroom behavior. When students receive a token for positive behavior, a splashing noise is heard. When a student receives a reminder, a bell is heard, and when a warning is given out, a thunderclap goes off. The sound is intended to help the students connect their behaviors with either a reward (+1 token) or punishment (unpleasant sound and/or time-out from receiving tokens if given a warning). This characteristic is implemented to avoid the practitioner calling out or disrupting the class after inputting behavioral data, but rather the students can be alerted and turn their attention to the display at the front of the room.

Typically, practitioners juggle data collection and verbal feedback to students as separate activities, and we found that the burden on them to provide verbal feedback each time a behavior occurred led to significant inconsistency. Inconsistent feedback from practitioners confused students. Feedback provided via the display prototype could prevent the practitioner from having to call out or disrupt the class in order to provide verbal feedback to a student who may be across the room. In this way, the classroom display application could be the most immediate, reliable, and consistent form of feedback that can be used in current practice.

6 DESIGN VALIDATION

As our research process was iterative, the display prototype went through multiple design iterations, all of which were discussed and validated with our research team, the regular education teacher, Mr. Newman, and the consulting behavior analyst. Next, we describe some examples of how the display prototype design process was evolved.

During the first iteration, each student's lily pad contained their total tokens, as well as four color-coded bubbles that corresponded with the categories in which tokens could be earned. When a student received a warning, their lily pad turned grey, and their avatar

Reward	Tokens
Homework Pass	25
Simon Says Leader	20
Show+Tell/Computers	15
Reading/Drawing	10
Candy	7

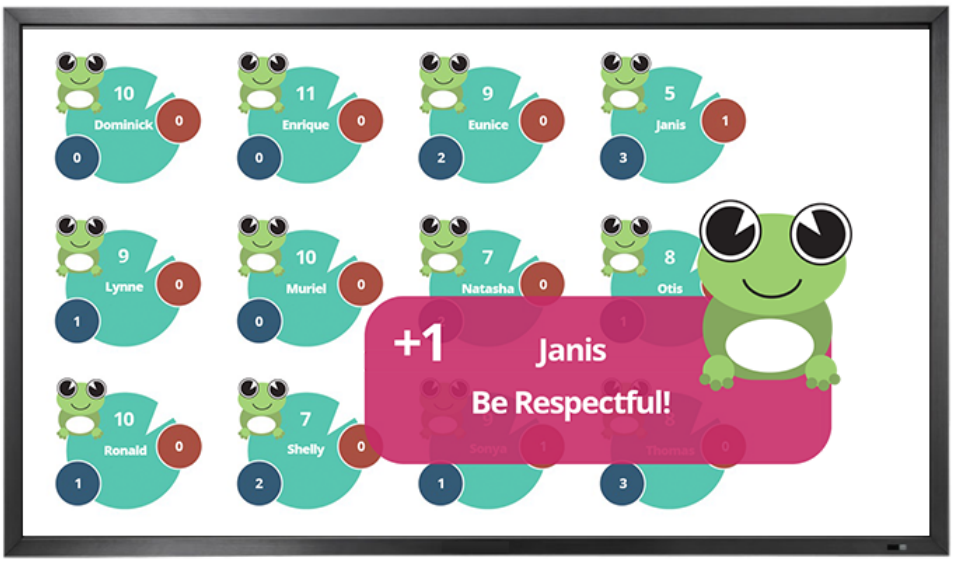

Figure 2: The classroom display was mounted at the front of the classroom, along with a rewards menu posted next to it. The display showed each students' lily pad containing their tokens earned and number of reminders (blue circle) and warnings (red circle) received. A pop-up message appears in the foreground with feedback for Janis about the behavioral category for which she has just earned a token: "Be Respectful!".

changed color and emotion (Figure 3). This signified that the student had received too many warnings and was now in 'timeout' from being able to earn any positive tokens. The text that appeared with the token or warning was a lot lengthier, causing the font to be small.

While the first iteration was visually pleasing, it did not address all of the practitioners' needs and posed concerns for the consulting behavior analyst. Having four separate bubbles for each behavior category caused each lily pad to look crowded and caused confusion. Also, one of the practitioners, Mr. Newman, was observed not using all of the reward categories available to him, signaling the categorized information to be a useless projection for students, and only total tokens were needed to be displayed. To address this, student's lily pads were changed to only display total number of tokens earned. In order to still provide behavior specific feedback to students, the category their token was earned in was included in the pop-up message.

Additionally, the consulting behavior analyst expressed concerns about the length and language used in the first iteration of the pop-up message. To address this concern, the message was changed to include the students' name and the behavior category in which their token was earned. This alleviated concerns of reading levels not being the same class-wide and student's not having enough time to read the entire message before it disappeared.

Finally, questions were raised regarding which type of information should be shown on a public classroom display, and how it would affect the students. To combat any issues of ostracisation, as well as elevate any parent concerns, the only data displayed are positive reinforcer tokens, reminders and warnings to help students awareness of their behaviors and the consequences associated with them. Both the positive reinforcer tokens and corrective behavior messages would mimic what practitioners would verbally announce to students when these instances occurred.

7 DEPLOYMENT

We iterated on the design until we determined together with practitioners that it was ready for use, and then we deployed the classroom display prototype in Mr. Newman's first-grade classroom. His classroom contained 19 students, under the consultation of a behavior analyst. The deployment lasted for ten months out of the school year, during which time we continued our fieldwork, including naturalistic observation and interviews twice a week. At the end of each week, we interviewed Mr. Newman about his experiences and attitudes toward the display. These interviews focused on the display's impact on his implementing of the token economy, as well as its effects on his students. The consulting behavior analyst was interviewed approximately every week when scheduling permitted. She was also interviewed at the conclusion of the study (end of the school year) to gather her overall impressions and expert opinion on the implementation of the classroom display. In this section, we describe findings from inductive thematic analysis of observation and interview data.

7.1 Awareness of collective classroom behavior

After the first week of the display being in the classroom, students were visibly responding to the sound effects. We observed students looking up at the display every time they heard the reward splash noise or the reminder thunderclap, intrigued to see who had received it. On average, Mr. Newman would give out two rewards

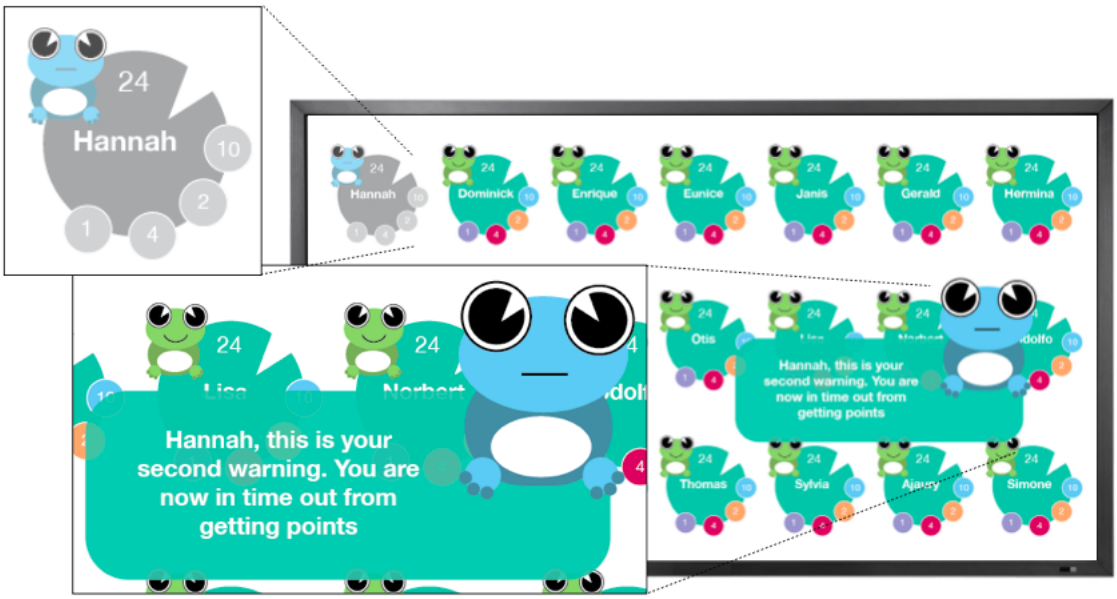

Figure 3: The first iteration of the display application.

per student per period and give out one to two reminders per class period, depending on individual student behavior.

Our research team was interested to see how students responded to the classroom display and if any potentially negative consequences came from displaying each student's tokens. There had been previous concerns voiced about the type of impact the display would have on student's behavior and its impact on the classroom dichotomy. The consulting behavior analysts and Mr. Newman both agreed that the display not only had a positive impact on student's individual behaviors, but also on the classroom dynamic, as well as provided students with immediate behavior specific feedback.

We considered the potential for a classroom display to have adverse effects such as competition or public shaming among the students. The consulting behavior analyst explained that such effects would be largely dependent on the general classroom environment the teacher has created. In the case of Mr. Newman's class, she said *"the kids were absolutely bought in to the fact that they were a team together. If that didn't exist then I think you would potentially see more [negative competition due to the display]"*. We recommend further investigation of potential unintended consequences, especially as they are so dependent on other factors within the classroom environment.

Students were observed continuously keeping tabs on their behavior via the classroom display. Due to the sound feature, students were constantly aware when they were receiving a token or a behavior correction. Every time a sound went off on the display, students were alert and eager to see who was on the receiving end of it. Commenting on her observations of the display and Mr. Newman's students, the consulting behavior analyst expressed:

> *"the students were visibly responding to the display. It was objectively observable that a noise associated with or affiliated with the [token economy] system had an immediate impact on the [student's] behavior".*

On multiple occasions, if the student who received a token was not paying attention, their classmates would get their attention and either congratulate them on earning a reward, or let them know their behavior needed correcting. Since the students were observed visibly responding to the display every time it made a sound, concerns were raised about its potentially disruptive nature. However, the sounds were found to be less disruptive than the practitioner calling out to either praise or correct a student for their behavior.

The sense of community that the display created in the classroom was shown to add an extra layer of motivation for the students. Students were observed making sure Mr. Newman was awarding tokens to peers who deserved them. Students would raise their hands to tell Mr. Newman if someone's token amount looked low based on the way they were positively behaving that day. In one instance, Mr. Newman had just given out some tokens to students who were quietly waiting for the math lesson to start. One student who had received a token raised his hand to say, *"Mr. [Newman], Lisa was also sitting quietly but she didn't get a point"*. This is one example of how students were seen looking out for one another while the display was in the classroom, displaying a sense of camaraderie and community.

7.2 Rewards menu as a main motivator

Prior to the display being deployed, Mr. Newman relied solely on verbal praise to give his students feedback on their behaviors. Other reinforcers such as candy or stickers were random occurrences. The consulting behavior analyst expressed that practitioners' prior behavior management methods were inconsistent and sometimes

ineffective. His rewards were also not motivating for all of his students. Recalling the difference in student behavior when the rewards menu was introduced, verses when the practitioner was only giving out candy as a reward: *"offering the kids choice in and of itself was very very motivating for these kids. Especially when they recognized that more points offered more choice"*.

Another noticeable difference was seen in individual student behaviors as well. Prior to the display and the rewards menu, one student, who was extremely chatty in class was not motivated by earning candy at the end of the day. This resulted in his talkative behavior going unchanged. Once the rewards menu was introduced, and this student now had options, he made an announced to his peers and Mr. Newman that he wanted to achieve the *"show + tell"* reward. With this reward, he could sing for the class at the end of the day, proving to be an effective motivator for this student to remain more quiet during class time.

The rewards menu was used by Mr. Newman to remind students whose behavior was starting to decline that if they wanted to earn a certain reward, they needed to show appropriate behavior. This became a huge motivator for students because they were able to individually pick their preferred reward to work towards earning each day.

7.3 Sharing behavioral data outside the classroom

Students reported going home and sharing information with their parents and guardians about the display. This included how many tokens they earned that day and which rewards they wanted to get. With the goal of the display being to make students more aware of their behavioral data, the unexpected consequence of them sharing their data with guardians at home was a interesting finding. On one occasion a student walked into the classroom in the morning exclaiming *"[Mr. Newman]!, I told my mom that I'm going to get that homework pass today!"*. Instances like this continued to occur during the deployment, highlighting the display's potential in helping to connect the students' home and school lives.

8 DISCUSSION

Our methodology builds on human-centered design concepts of involving stakeholders and expert input in the design process. We have described a collaborative research process with school practitioners motivated to improve their behavior management programs by helping students to be more aware of their behavioral data. From our action research process, we identified the challenges that practitioners were having in implementing an effective token economy according to Metzler *et al.*'s [30] features. With our vision of pervasive computing, the classroom display prototype contributed at some level to each of the challenges we found in these features.

1) Increasing positive reinforcers for appropriate social behavior and 2) Active teaching of appropriate social behavior: Our display prototype has the potential to encourage practitioners to record positive behaviors and teaching of appropriate behavior, since they are the input for the tokens that are shown in the prototype.

3) Clear communication of a small number of rules: Although the token economy that practitioners were using before the classroom display presented a small number of rules, the communication of these rules was not effective. Though the token economy rules did not change when incorporated into our prototype, the visibility and access for students to the display aided the communication of expectations from practitioner to students.

4) Consistent provision of corrective consequences for rule violation: Consistent implementation of corrective consequences is an important part of shaping student's behavior. The customizability of the classroom display enables practitioners to provide corrective feedback consistently and immediately to a student with reminders and warnings.

5) Ongoing monitoring data on student's behavior to provide feedback on progress: The classroom display prototype provides students with immediate and specific feedback on their behaviors. Students no longer need to ask for updates on how many tokens they earned or why they had earned them. Through the use of the display application, students are given the opportunity to monitor their behavior on a consistent basis and understand why they are receiving tokens or behavior corrections. The display therefore allows for the ongoing behavioral monitoring that can promote student awareness, without added work on the part of the practitioner.

Through its adherence to the token economy features and ability to be customized, the classroom display was designed to empower and engage students with their behavioral data that was being collected on them by practitioners. With the observed positive impact of the display on student's abilities to understand and manage their behavior, our design shows great potential for students and their behavioral awareness.

Our findings suggest the potential need for practitioners to place a greater emphasis on student awareness on behavioral data in the educational setting, through the facilitation of adaptable and customizable technology to support student self-management.

9 CONCLUSION

We identified a design opportunity to help students be aware of their behavioral data in the classroom setting. Based on the extensive ideations that our partnership with practitioners generated, we discussed our in-depth field work. The design opportunity provided a potential for improving the implementation of behavioral management programs and their suitability to pervasive computing tools: providing behavioral reinforcers and immediate feedback to students. Finally, we presented a promising tool for addressing this design opportunity: a classroom display prototype.

10 LIMITATIONS AND FUTURE WORK

Our research and prototype involved one small population. Our study mainly involved individuals from the regular education setting, which does pose concerns for the generalization of the findings. Future work should use a larger sample size to test the generalization of these findings. Future work should also complete the action research process and continue testing and observing the classroom display.

We purposefully chose to not involve children in the design process, in spite of our focus on them as end users. This decision enabled us to focus on formative exploration of concepts that would fit into classroom management practices, and engage with practitioners on improving their implementation fidelity. We worked

with behavior analysts to design around evidence-based strategies for managing individual behavior in the classroom. Our evaluation of the display prototype found that even though the students were not involved in the design process, they accepted and engaged with the prototype. Based on these promising results, future work should use cooperative inquiry [11] to refine the application we present here into interventions best suited for students themselves.

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