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 expectations are being met. These strategies promote mental health and support students with emotional or behavioral disabilities. Yet behavioral psychology literature indicates a significant gap between evidence-based strategies for behavior management, and implementation of these strategies in real classroom settings. 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 classroom display prototype, which we developed and deployed. We describe its integration into classroom flow, and discuss the role pervasive computing can play in promoting behavioral awareness and emotional well-being 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 in classrooms is one of the earliest mental health interventions children may be exposed to. Early intervention in schools is key to addressing emotional and behavioral disorders [6]. Problem behavior that is left untreated can affect other students, and can lead to long-term outcomes such as substance abuse, interactions with the criminal justice system, and mental health issues [35]. Classroom behavior management involves defining clear expectations and rules, providing specific feedback, and continuously adapting responses to behaviors of individual students [42]. These strategies are important for students with diagnoses such as attention-deficit/hyperactivity disorder, obsessive-compulsive disorder, or trauma. In addition, effective behavior management serves as a preventative measure for mental health of all students. Behavior management from an early age reduces problem behaviors, increases desired on-task and social behavior, and improves outcomes for young adults [23, 40, 42]. School practitioners across special education and regular education settings therefore draw from the same behavior management strategies informed by decades of evidence from behavioral psychology research [42].

However, there are challenges to effectively implementing behavior management strategies in the classroom. We investigate the role pervasive computing can play in helping classroom staff to implement behavior management strategies with high enough fidelity that they achieve efficacy. 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 [21]. Implementation fidelity can be increased through training [4] and consultation from school psychologists [34], but these approaches are resource intensive. Once achieved, high implementation fidelity is also difficult to sustain [40]. 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, 22]. 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 of 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 target behavior of working quietly, 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 [39]. In special education, token economies have demonstrated effectiveness in improving behaviors of students with behavioral disorders [37], autism spectrum disorders [27, 41], and intellectual disability [32]. Examples of efficacy studies in regular education include reducing disruptive behavior in a preschool classroom [15], improving student conduct in a fifth-grade classroom [2], and maintaining decreased inappropriate behavior in a ninth-grade classroom [26].

Despite the widespread use of token economies in classrooms, behavior problems persist, and the prevalence of serious emotional and behavioral disorders is estimated at 5% to 26% of children in the U.S. [6]. 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 [25]. School practitioners also do not have enough tools and support for implementing token economies [30]. More research has been recommended to identify supports that can help school practitioners ensure high fidelity of implementation with token economies [11].

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 [33] 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 [28], in individual behavioral therapy sessions [24], and other non-classroom contexts. Studies of pervasive computing integrated in classrooms to support behavior management have shown feasibility, acceptability, and efficacy across special education [20, 31] and regular education [9].

One gap we identified in the literature is that the majority of these tools are not designed for the needs of students, instead helping 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 [17, 29]. 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 [30] 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 [20]. 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. [31] 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 [9], 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 monitor 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 [18]. Pervasive computing technologies designed for children with

behavioral needs have largely been educational games and standalone therapeutic interventions [3, 7, 36, 38]. Despite the myriad 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 in daily life. Our work complements efforts to apply gamification in promoting healthy behavior by focusing on the integration of these strategies in classroom flow. Within Hervas et al.'s taxonomy of gamification mechanics for behavioral change, we specifically investigate the use of status through social sharing, and scoring through points earned for behaviors [19]. We also consider how student and teacher behaviors are intertwined [14], which requires an understanding of classroom dynamics.

Our design work in classrooms draws from school psychology literature at the intersection of special education and regular education settings—with a particular focus on the token economy, as previously outlined. 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 with support [10]. The additional support can be provided by practitioners in their school's resource room, school psychologists, or other specialists that serve their school district. More inclusive placement is generally viewed as beneficial for promoting a student's mental health and independence [10]. Research has indicated that students with behavioral needs *"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"* [12]. To address this need across a variety of classroom settings, we focus on conceptualizing an appropriate design that would fit existing classroom flows 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 classroom.

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 classrooms were located in the same school district, enabling us to understand how various stakeholders influenced implementation of behavior management strategies. In addition to classroom staff (teachers and paraprofessionals), we engaged with building-level and district-level stakeholders such as school psychologists and behavior analysts. They would provide consultation on individual cases as needed, visiting by request of classroom staff for direct observation of a student's behavior, and to advise on implementation of behavior management strategies.

Table 1: Summary of field sites, participants, and data collection methods. Classrooms represented both special (sped) and regular (reg) education. Practitioner roles with a * indicate they work across the school district.

Classroom	Students	Practitioners	Methods
A (sped)	n = 12 Grades K-3	n = 14 (teachers, paraprofessionals, school psychologist*, social worker*, consulting behavior analysts*)	Observation 250 hrs Interviews n=12 Focus Groups n=20
B (sped)	n =12 Grades 3-5		
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

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 comprised of children in grades K-5. Together with a supervising social worker across the hall, these two 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 behavioral 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.

Classroom D was a first grade regular education class, comprised of 19 students and one teacher, Mr. Newman[1]. Mr. Newman had shown an aptitude for working with children who exhibited disruptive behaviors. As a result, children tended to be put in his class 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 an informative context for our study, representing a bridge between special and regular education settings.

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 solutions [16]. The actors we engaged in this study are the 20 practitioners shown in Table 1, who worked across four classrooms in a range of roles. With these practitioners, we explored the challenges they face in implementing behavior management strategies, during 30 months of fieldwork, over 265 hours of naturalistic observation, 20 interviews, and 25 focus groups. 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.

3.2.1 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.

3.2.2 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).

3.2.3 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 how the prototype might affect practitioner workflow, student behaviors, and overall classroom dynamics. Together we then examined adoption of the prototype, and how it fit into classroom flow.

3.3 Human-Centered Design

A key theme that emerged from action research 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, which enabled us to explore design opportunities in depth. Needs and constraints we found throughout the action research process informed our design work. This iterative process is illustrated on the right side of Figure 1. By continuing discussions of the challenges we identified during classroom observations and preliminary diagnosis, we engaged practitioners in ideations 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 similar technology. The rest of our human-centered design process focused on the needs and constraints of classroom D.

4 FINDINGS

During action research, we identified challenges to implementing a token economy in the classroom. Two design opportunities then emerged, based on the potential for pervasive computing technologies to support individualized feedback and reinforcement for each student's unique behaviors.

4.1 Classroom Challenges

As we investigated interactions between practitioners and students, we identified challenges related to each of Metzler er al.'s [33] five features of an effective token economy.

4.1.1 Increasing positive reinforcers for appropriate social behavior. Inappropriate behaviors tended to occupy practitioners' time because they needed immediate correction, so appropriate behavior frequently went unacknowledged.

4.1.2 Active teaching of appropriate social behavior. Interactions with practitioners and peers were most important for students to learn appropriate social behavior. Opportunities for these interactions were reduced after a serious behavioral incident due to required paperwork and coordination.

4.1.3 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 child did not understand why they had earned or lost points.

4.1.4 Consistent provision of corrective consequences for rule violation. A low student–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 was sent to the office, while the other was put in an isolated area called the 'cool-down room'.

4.1.5 Ongoing monitoring of data on student behavior to provide feedback on progress. Practitioners monitored behaviors for their own awareness, while students frequently requested updates about their tokens earned. Feedback was primarily given verbally, which was demanding on practitioners' time and focus, and therefore inconsistent.

[1] All names are pseudonyms.

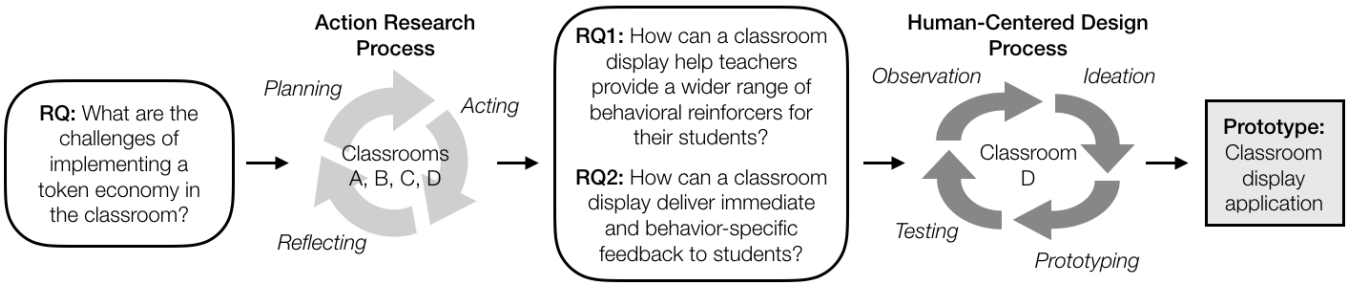

Figure 1: Methods

4.2 Limitations of Existing Technologies

As we began to ideate and searched for the most actionable design opportunities, we learned that classroom D's teacher, Mr. Newman, had incorporated ClassDojo (a popular educational technology product[2]) to display his classroom's token economy during the previous school year. He appreciated that it gave him a way to display students' behavioral data, however 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 he had only been able to do this periodically because he did not have a dedicated display for it. He was also not able to customize ClassDojo to each student's behavior management plan, because its functionality provided a limited set of options.

A behavior analyst consulting in Mr. Newman's school district also suggested the need for a customizable pervasive technology to aid with improving student's behavioral awareness. In her experience watching Mr. Newman use ClassDojo in the past, she did not notice any effects on the students. She suggested there could be positive effects if such a tool fit alongside existing practices by promoting structure within the classroom, so that students could receive more frequent behavioral feedback from the practitioner or the technology. In classroom D, she explained that half of the students were engaging in behaviors that were primarily attention seeking, for example not sitting in their chairs and not listening to activities or instructions. Her assessment suggested that in this classroom, implementing 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 agreed that a classroom display could be used for supporting student awareness of their behaviors, by providing easily accessible feedback to all students simultaneously. We leveraged practitioners' experiences 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.

4.3 Design Opportunities

We found that 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 in constant supply. Candy, toys, and privileges were commonly offered as rewards, but 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 it 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 an effective token economy [33]. As we observed practitioners logging tokens to monitor progress toward rewards, we found that little to none of this process was designed to actively help student awareness 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 were provided with paper charts on their desks, on which to track progress to a reward on their own. Mr Newman 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 it was earned. These needs led us to **RQ2: How can a classroom display deliver immediate and behavior-specific feedback to students?**

Driven by these research questions, we performed an iterative human-centered design process informed by what we learned about behavior management across a range of classrooms during action research (Figure 1). We co-designed, deployed, and iterated on a classroom display application, with a focus on its integration into existing classroom practices, and reducing the likelihood of unintended effects such as causing distractions or burdening practitioners with additional work. In the following section, we describe the design of the prototype.

5 CLASSROOM DISPLAY PROTOTYPE

Our resulting prototype was a wall-mounted classroom display (Figure 2) that enables all students in the classroom to continuously check their tokens and behaviors throughout the school day. A practitioner uses a tablet interface to log tokens in a format that

[2]https://www.classdojo.com/

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

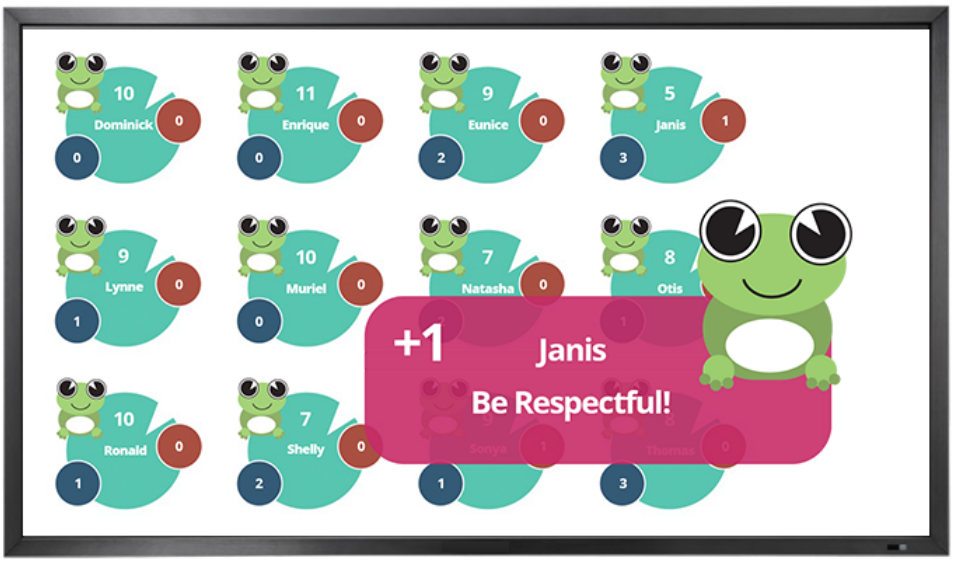

Figure 2: The classroom display was mounted at the front of the classroom, along with a rewards menu next to it, printed on paper. The display contained each students' lily pad showing the tokens, reminders (blue circle), and warnings (red circle) they had received that day. A pop-up message appears in the foreground with behavioral feedback for Janis.

helps them monitor behaviors, while the display pulls that data in real-time to generate a visualization tailored to the needs of students. Every time a student receives a token, two types of immediate reinforcers are delivered: a pleasant splash sound, and a pop-up graphic naming the student and the behavioral category in which they earned the token. The design of the prototype aims to help students connect a reinforcer to the behavior it is meant to reinforce, through automated feedback. Next, we describe the characteristics of the prototype and how each design decision was made to address the opportunities we identified during the action research phase.

5.1 Helping Teachers Provide a Range of Behavioral Reinforcers

Teachers needed support in providing behavioral reinforcers to students, which would be simple to keep in stock and distribute throughout the day, while still serving to motivate students in following behavioral rules.

5.1.1 Token Economy. The prototype was designed to mimic how token economies were implemented in the classrooms we observed, while digitizing the distribution of tokens. The practitioner uses a tablet-based interface to record students' tokens. Students can earn tokens for desired behavior in four behavioral categories: be helpful, be responsible, be respectful, and be safe. Students can receive tokens at any time throughout the day, and after each period, each student's behavior is evaluated for that block of time, and they are given an additional token for no rule violations. The prototype also enables the practitioner to give students warnings and reminders. Reminders were used for minor behavior corrections, while warnings were reserved for more serious offenses and usually given out after a reminder if the behavior persisted.

5.1.2 Rewards Menu. A rewards menu was printed on paper and hung on the wall next to the display as shown in Figure 2, helping practitioners communicate the availability of a wider range of rewards, and serving as a visual reminder students of how many tokens were needed for each. The prominent placement of the rewards menu next to the display, which showed real-time status of tokens earned, 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.

5.1.3 Customization. One of the novel features of the prototype, 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 rules as is typically done with token economies, monitoring unique behaviors for each student allows tokens to provide reinforcement that is more specific and helpful for students. In addition, as students make progress, monitoring can be updated to reflect new goals. For example, a student working on social interactions can be provided with different types of interactions to work on more concretely over time, such as turn-taking and sharing.

5.2 Providing Students with Immediate and Specific Feedback

Due to the demands of managing behaviors in a classroom, we found that teachers struggled to provide immediate and specific feedback on behaviors using the common verbal approach. Our prototype

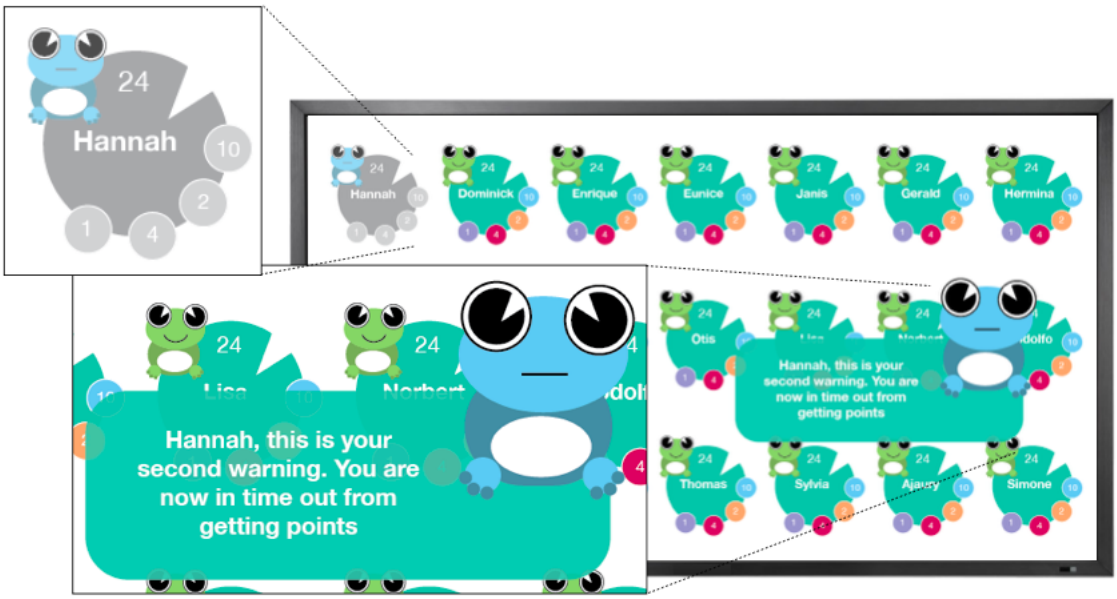

Figure 3: The first iteration of the classroom display prototype.

was designed to supplement verbal feedback from practitioners, through automated delivery of feedback directly to students.

5.2.1 Visual Feedback. The prototype is designed as a glanceable display [8], 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, as illustrated in Figure 2. 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 in the design, which significant evidence suggests is most effective for behavior management, but practitioners did not find this approach feasible for use in their classrooms. In reality, we found that all four classrooms we studied used some form of punishment-based reinforcers, such as the reminders and warnings. With the consulting behavior analyst, we devised a system whereby persistent disruptive or undesired behavior would result in a warning, which placed students on 'time-out', making them temporarily ineligible to earn tokens. This compromise in the design enabled practitioners to still enforce consequences without using punishment-based reinforcers or removing previously earned tokens.

5.2.2 Auditory Feedback. Auditory feedback had been a feature of ClassDojo that Mr. Newman found particularly useful, and he found was well-liked by his students. We therefore incorporated audio feedback to alert students each time the practitioner awarded a token using his tablet interface. A sound is played immediately when students receive a token for desired behavior and when they receive a warning or reminder for demonstrating violations of behavioral rules. A token for desired behavior is associated with a splash noise. A reminder or warning is associated with a bell or thunderclap, respectively. The sound is intended to help the students connect their behaviors with either a reward or correction.

This feature addresses the challenges of practitioners needing to provide verbal feedback to each student. Typically, practitioners juggle data collection and verbal feedback to students as separate activities, and we found that the burden of providing feedback each time a behavior occurred led to significant inconsistency. Inconsistent feedback from practitioners consequently confused students. By automating feedback via the display prototype, our aim was to enable more reliable and immediate feedback to students.

6 DESIGN VALIDATION

The display prototype went through multiple iterations, all of which were discussed and validated among our research team, the regular education teacher we were designing for (Mr. Newman), and the behavior analyst providing consultation for his classroom. Validating the design involved mediating evidence-based implementation of behavioral strategies with real-world classroom constraints. In addition, iterations of the design were focused on mediating the needs of the teacher (low burden and effort) and his students (high quality feedback).

The first iteration of the prototype is shown in Figure 3. In this version, each student's lily pad included additional detail about their behavioral data, using four distinctly colored bubbles that corresponded to the categories in which tokens could be earned. We found that this amount of detail made the visual too crowded and difficult to read, while students were primarily interested in their total number of points, displayed at the top of their lily pad. We therefore simplified lily pads to only display total number of tokens earned, so this information could be easier to check at a glance. In order to still provide specific feedback to students about their behavior, the category their token was earned in was included

in the pop-up message. For example, the final design in Figure 2 contains a pop-up alert that Janis has earned a point in the "Be Respectful" category. The text of this pop-up was also simplified from a lengthier version visible in Figure 3, due to the behavior analyst's concerns about varying reading levels in the classroom, and her wanting to ensure students would be able to read the entire message quickly enough while glancing up at the display.

Lastly, the initial version in Figure 3 contained signifiers that the behavior analyst deemed potentially problematic. When a student received a warning, their lily pad turned grey, and their frog changed color and emotion. These elements were intended to signify that the student was now in 'timeout' from being able to earn any tokens. Both the tokens awarded and corrective behavior messages were designed to mimic what practitioners would verbally announce to students when these instances occurred. However, the behavior analyst expressed concerns about how their visual representation would affect the students. We therefore simplified the design and removed signifiers that could be interpreted with negative affect. We found ways to still clearly communicate to students their status, while maintaining a more neutral tone.

7 DEPLOYMENT

We iterated on the design until we determined together with practitioners that it was ready for use, then 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 of the school year, during which 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 implemention 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 end of the deployment, to gather her overall impressions and expert opinion on the use of the classroom display. Observation and interview data were compared and the findings in this section were derived using inductive thematic analysis.

7.1 Collective Awareness of 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 a splash, bell, or thunderclap sound, intrigued to see who had received it. On average, Mr. Newman would give out two tokens per student per period, and one to two reminders per class period, depending on individual student behavior.

A key focus of our deployment was to see how students responded to the classroom display and if any potentially negative consequences came from publicly displaying each student's tokens. There had been some initial concerns about the impact the display might have on student behavior and the classroom as a whole. However, the behavior analyst and Mr. Newman both agreed that the display had a positive impact on student's individual behaviors and the classroom dynamic, and also provided students with immediate feedback on their behaviors.

We considered the potential for a classroom display to have adverse effects such as competition or a sense of public shaming among the students. The 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 since they are dependent on other factors within the classroom environment.

Students were observed continuously monitoring their tokens via the classroom display. With the sound feature, students were constantly aware when they were receiving a token or behavior correction. Every time a sound went off on the display, students were alert and eager to see which name it was associated with. In her observations of the display in Mr. Newman's classroom, the behavior analyst noticed:

> *"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 the same information.

The fact that the display was able to fit in with a sense of community in the classroom added another 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 count seemed low based on their actual behavior 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 the display encouraged peer support and encouragement.

7.2 Motivating the Token Economy

Combining a real-time indicator of a student's number of earned tokens, with a rewards menu showing what they could exchange their tokens for, proved to be motivating for students. Before the display prototype was deployed, Mr. Newman relied solely on verbal praise to give his students feedback on their behaviors. Other reinforcers such as candy were utilized occasionally. The behavior analyst described these prior behavior management strategies as inconsistent and sometimes ineffective. The rewards offered were not always motivating for his students. The behavior analyst noticed a significant change when the rewards menu was introduced: *"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"*.

Mr. Newman referenced the rewards menu 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 significant motivator for students because they were able to individually pick their preferred reward to work toward each day. For example, one student was very talkative in class. Before the deployment he was not motivated to curb his verbal behavior because Mr. Newman only provided candy rewards, which he did not find desirable. Once the rewards menu was introduced alongside the display, it showcased a range of rewards available. This student was particularly interested in "Show + Tell", which allowed him the opportunity to sing for the class at the end of the day. As a result, he announced to the class that he would be working toward this reward, and it served as an effective motivator for him to remain more quiet during class time. Notably, this change in behavior was accomplished without the need to stock a supply of tangible items or edibles such as candy. Instead, the display at the front of the room served to showcase high-value rewards that did not add burden for the teacher to provide.

Students also reported going home and sharing information with their parents about the display, such as how many tokens they earned that day and which rewards they were working toward. This kind of communication shows that students had sustained awareness of their behaviors. In addition to the communication and encouragement we observed in the classroom among peers, the ability to bridge students' home and school environments is important for effective behavior management. One morning, a student walked into the classroom proclaiming which item on the rewards menu he was determined to earn: *"[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 social role within and beyond the classroom. This finding suggests that pervasive computing has the potential to connect students' home and school lives for more consistent and motivating behavior management.

8 DISCUSSION

Our methodology builds on human-centered design concepts of involving stakeholders and expert input in the design process, by using principles of action research. 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. Findings from a deployment of our prototype show that integrating pervasive computing into the daily flow of a classroom can help to support implementation of an effective token economy, as defined by Metzler et al.'s five 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 desired behaviors and teach appropriate behavior, since they provide the input that is publicly displayed in real-time for the classroom to engage with collectively.

(3) Clear communication of a small number of rules: Students were being asked to follow a small number of rules, however these were not always clearly communicated. With our display prototype, the visibility and access to a real-time status of their behaviors against the rules aided in clear communication of the behaviors that were expected of them.

(4) Consistent provision of corrective consequences for rule violation: Corrective consequences were difficult for practitioners to provide consistently. With the classroom display, students were provided corrective feedback more consistently and immediately through the use of visual and audio alerts.

(5) Ongoing monitoring of behavior to provide feedback on progress: Our display prototype provided ongoing monitoring and feedback on the students' progress throughout the day. Practitioners did not previously have any tools to support this process on an ongoing basis, and to our knowledge ours is the first pervasive computing system in the literature to enable this process. Students no longer needed to ask for updates on how many tokens they had earned, or clarification on why they had earned them.

This study describes a positive role pervasive computing can play in the classroom to support behavior management strategies. Classroom displays can help improve the consistency, reliability, and clarity with which behavioral feedback is provided to students. Practitioners are monitoring behaviors and often recording them for their own use, and we leveraged these existing tasks to design automated audiovisual feedback to students about their individual behavior. The public nature of a classroom display has risks for causing embarrassment or competition. However, by designing more neutral signifiers and integrating the display into a collaborative classroom culture, we found that the display encouraged prosocial behavior and peer support toward behavioral goals.

Our research and prototype have several limitations. An initial deployment was conduced in one classroom, and more studies are needed to understand how the display will fit in various classrooms, for example with different teaching styles, learning culture, and student group dynamics. We 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 also 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 [13] to refine the application we present here into interventions best suited for and preferred by students themselves.

9 CONCLUSION

We identified design opportunities for supporting behavior management in the classroom setting. We have discussed in-depth fieldwork with extensive ideation that our partnership with practitioners generated. Our design work together focused on improving the implementation of behavior management strategies and their suitability to pervasive computing tools. This exploration culminated in the design and deployment of a classroom display that helped a teacher to provide a broader range of behavioral reinforcers, and more immediate feedback on behaviors.

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REFERENCES

[1] Teodoro Ayllon and Nathan Azrin. 1968. The token economy: A motivational system for therapy and rehabilitation. (1968).

[2] Victoria Besalel-Azrin, Nathan Azrin, and P.M. Armstrong. 1977. The student-oriented classroom: A method of improving student conduct and satisfaction. *Behavior Therapy* 8, 2 (1977), 193–204.

[3] LouAnne E. Boyd, Kathryn E. Ringland, Oliver L. Haimson, Helen Fernandez, Maria Bistarkey, and Gillian R. Hayes. 2015. Evaluating a collaborative iPad game's impact on social relationships for children with autism spectrum disorder. *ACM Transactions on Accessible Computing (TACCESS)* 7, 1 (2015), 3.

[4] Catherine P. Bradshaw, Mary M. Mitchell, and Philip J. Leaf. 2010. Examining the effects of schoolwide positive behavioral interventions and supports on student outcomes: Results from a randomized controlled effectiveness trial in elementary schools. *Journal of Positive Behavior Interventions* 12, 3 (2010), 133–148.

[5] Catherine P. Bradshaw, Wendy M. Reinke, Louis D. Brown, Katherine B. Bevans, and Philip J. Leaf. 2008. Implementation of school-wide positive behavioral interventions and supports (PBIS) in elementary schools: Observations from a randomized trial. *Education and Treatment of Children* 31, 1 (2008), 1–26.

[6] Cheryl Boydell Brauner and Cheryll Bowers Stephens. 2006. Estimating the prevalence of early childhood serious emotional/behavioral disorders: Challenges and recommendations. *Public health reports* 121, 3 (2006), 303–310.

[7] Karina Caro, Mónica Tentori, Ana I. Martinez-Garcia, and Marina Alvelais. 2017. Using the FroggyBobby exergame to support eye-body coordination development of children with severe autism. *International Journal of Human-Computer Studies* 105 (2017), 12–27.

[8] Sunny Consolvo, Predrag Klasnja, David W. McDonald, Daniel Avrahami, Jon Froehlich, Louis LeGrand, Ryan Libby, Keith Mosher, and James A. Landay. 2008. Flowers or a robot army?: Encouraging awareness & activity with personal, mobile displays. In *Proceedings of the 10th international conference on Ubiquitous computing*. ACM, 54–63.

[9] Meg Cramer and Gillian R. Hayes. 2013. The digital economy: A case study of designing for classrooms. In *Proceedings of the 12th International Conference on Interaction Design and Children*. ACM, 431–434.

[10] Jean B Crockett and James M Kauffman. 2013. *The least restrictive environment: Its origins and interpretations in special education.* Routledge.

[11] Christopher Doll, Tim McLaughlin, and Anjali Barretto. 2013. The token economy: A recent review and evaluation. *International Journal of basic and applied science* 2, 1 (2013), 131–149.

[12] Steve M. Dorman. 1998. Assistive technology benefits for students with disabilities. *The Journal of school health* 68, 3 (1998), 120.

[13] Allison Druin. 1999. Cooperative inquiry: developing new technologies for children with children. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*. ACM, 592–599.

[14] Susan Elswick and Laura Baylot Casey. 2011. The Good Behavior Game Is No Longer Just an Effective Intervention for Students: An Examination of the Reciprocal Effects on Teacher Behaviors. *Beyond Behavior* 21, 1 (2011), 36–46.

[15] Holly A. Filcheck, Cheryl B. McNeil, Laurie A. Greco, and Rebecca S. Bernard. 2004. Using a whole-class token economy and coaching of teacher skills in a preschool classroom to manage disruptive behavior. *Psychology in the Schools* 41, 3 (2004), 351–361.

[16] Gillian R. Hayes. 2011. The relationship of action research to human-computer interaction. *ACM Trans. Comput.-Hum. Interact.* 18, 3, Article 15 (Aug. 2011), 20 pages.

[17] Gillian R. Hayes, Lamar M. Gardere, Gregory D. Abowd, and Khai N. Truong. 2008. CareLog: A selective archiving tool for behavior management in schools. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 685–694.

[18] Gillian R. Hayes, Sen Hirano, Gabriela Marcu, Mohamad Monibi, David H. Nguyen, and Michael Yeganyan. 2010. Interactive visual supports for children with autism. *Personal and ubiquitous computing* 14, 7 (2010), 663–680.

[19] Ramon Hervas, David Ruiz-Carrasco, Tania Mondejar, and Jose Bravo. 2017. Gamification mechanics for behavioral change: a systematic review and proposed taxonomy. In *Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare*. ACM, 395–404.

[20] Sen H. Hirano, Michael T Yeganyan, Gabriela Marcu, David H. Nguyen, LouAnne Boyd, and Gillian R. Hayes. 2010. vSked: evaluation of a system to support classroom activities for children with autism. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 1633–1642.

[21] Robert H. Horner, Anne W. Todd, Teri Lewis-Palmer, Larry K. Irvin, George Sugai, and Joseph B. Boland. 2004. The school-wide evaluation tool (SET) a research instrument for assessing school-wide positive behavior support. *Journal of Positive Behavior Interventions* 6, 1 (2004), 3–12.

[22] Alan Kazdin. 2012. *The token economy: A review and evaluation.* Springer Science & Business Media.

[23] Sheppard G. Kellam, C. Hendricks Brown, Jeanne M. Poduska, Nicholas S. Ialongo, Wei Wang, Peter Toyinbo, Hanno Petras, Carla Ford, Amy Windham, and Holly C. Wilcox. 2008. Effects of a universal classroom behavior management program in first and second grades on young adult behavioral, psychiatric, and social outcomes. *Drug and alcohol dependence* 95 (2008), S5–S28.

[24] Julie A. Kientz, Sebastian Boring, Gregory D. Abowd, and Gillian R. Hayes. 2005. Abaris: Evaluating automated capture applied to structured autism interventions. *UbiComp 2005: Ubiquitous Computing* (2005), 903–903.

[25] Daniel M. Maggin, Sandra M. Chafouleas, Katelyn M. Goddard, and Austin H. Johnson. 2011. A systematic evaluation of token economies as a classroom management tool for students with challenging behavior. *Journal of School Psychology* 49, 5 (2011), 529–554.

[26] George C. Main and Barry C. Munro. 1977. A token reinforcement program in a public junior-high school. *Journal of Applied Behavior Analysis* 10, 1 (1977), 93–94.

[27] Brent Mangus, Hester Henderson, and Ron French. 1986. Implementation of a token economy by peer tutors to increase on-task physical activity time of autistic children. *Perceptual and Motor Skills* 63, 1 (1986), 97–98.

[28] Gabriela Marcu, Anind K. Dey, and Sara Kiesler. 2012. Parent-driven use of wearable cameras for autism support: a field study with families. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*. ACM, 401–410.

[29] Gabriela Marcu, Anind K. Dey, Sara Kiesler, and Madhu Reddy. 2016. Time to Reflect: Supporting Health Services over Time by Focusing on Collaborative Reflection. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW '16)*.

[30] Gabriela Marcu, Kevin Tassini, Quintin Carlson, Jillian Goodwyn, Gabrielle Rivkin, Kevin J. Schaefer, Anind K. Dey, and Sara Kiesler. 2013. Why do they still use paper?: Understanding data collection and use in autism education. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*. 3177–3186.

[31] Aleksandar Matic, Gillian R. Hayes, Monica Tentori, Maryam Abdullah, and Sabrina Schuck. 2014. Collective use of a situated display to encourage positive behaviors in children with behavioral challenges. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. ACM, 885–895.

[32] Johnny L. Matson and Jessica A. Boisjoli. 2009. The token economy for children with intellectual disability and/or autism: A review. *Research in Developmental Disabilities* 30, 2 (2009), 240–248.

[33] Carol W. Metzler, Anthony Biglan, Julie C. Rusby, and Jeffrey R. Sprague. 2001. Evaluation of a comprehensive behavior management program to improve school-wide positive behavior support. *Education and Treatment of Children* 24, 4 (2001), 448–479.

[34] George H. Noell, Gary J. Duhon, Susan L. Gatti, and James E. Connell. 2002. Consultation, follow-up, and implementation of behavior management interventions in general education. *School Psychology Review* 31, 2 (2002), 217.

[35] H.R. Perkins and T.F. McLaughlin. 2015. Classroom interventions for elementary school children with EBD: A brief review. *International Journal of Applied Research* 1, 4 (2015), 24–29.

[36] Anne Marie Piper, Eileen O'Brien, Meredith Ringel Morris, and Terry Winograd. 2006. SIDES: a cooperative tabletop computer game for social skills development. In *Proceedings of the 2006 Conference on Computer Supported Cooperative Work*. ACM, 1–10.

[37] Henry C. Rickard, Kenneth B. Melvin, Joe Creel, and Laura Creel. 1973. The effects of bonus tokens upon productivity in a remedial classroom for behaviorally disturbed children. *Behavior Therapy* 4, 3 (1973), 378–385.

[38] Kathryn E. Ringland, Rodrigo Zalapa, Megan Neal, Lizbeth Escobedo, Monica Tentori, and Gillian R. Hayes. 2014. SensoryPaint: A Multimodal Sensory Intervention for Children with Neurodevelopmental Disorders. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '14)*. ACM, New York, NY, USA, 873–884. https://doi.org/10.1145/2632048.2632065

[39] Brandi Simonsen, Sarah Fairbanks, Amy Briesch, Diane Myers, and George Sugai. 2008. Evidence-based practices in classroom management: Considerations for research to practice. *Education and treatment of children* 31, 3 (2008), 351–380.

[40] George Sugai and Robert R. Horner. 2006. A promising approach for expanding and sustaining school-wide positive behavior support. *School Psychology Review* 35, 2 (2006), 245.

[41] Rachel S.F. Tarbox, Patrick M. Ghezzi, and Ginger Wilson. 2006. The effects of token reinforcement on attending in a young child with autism. *Behavioral Interventions* 21, 3 (2006), 155–164.

[42] Richard M. Wielkiewicz. 1995. *Behavior management in the schools: Principles and procedures.* Allyn & Bacon, Needham Heights, MA, USA.