

# Collective use of a Situated Display to Encourage Positive Behaviors in Children with Behavioral Challenges

Aleksandar Matic<sup>1</sup>, Gillian R. Hayes<sup>2</sup>, Monica Tentori<sup>3</sup>, Maryam Abdullah<sup>4</sup>, Sabrina Schuck<sup>4</sup>

<sup>1</sup>Telefonica Research\*  
Barcelona, Spain  
amatic@tid.es

\*the work was done when the author was working at CREATE-NET, Italy

<sup>2</sup>Department of Informatics  
University of California,  
Irvine,  
gillianrh@isc.uci.edu

<sup>3</sup>Department of  
Computer Science,  
CICESE, Mexico  
mtentori@cicese.mx

<sup>4</sup>UCI Child Development  
School, Irvine, USA  
{mabdulla,  
sabrina}@uci.edu

## ABSTRACT

Situated displays can support behavior management for children with behavioral challenges. However, existing tools are often static, rarely engaging, and tend to focus only on individual behavior. In this work, we designed and deployed a situated display to support teamwork and cooperation in children with behavioral challenges. We evaluated this tool in two classrooms of a public school specializing in behavioral interventions with 28 children over four weeks. The results of this work demonstrate that situated displays focused on collective behavioral performance can support reflection on individual performance, improve behavior for students with behavioral challenges, as well as encourage teamwork and cooperative behavior in classrooms. These results also indicate a variety of issues to be considered when designing situated displays for these environments, including considerations for the representation of ambiguity and failure as well as the relationship between novelty and engagement.

## Author Keywords

Large displays; education; behavioral intervention; groups.

## ACM Classification Keywords

K.3.1 Computer Uses in Education; K.4.2 Social Issues- Assistive technologies for persons with disabilities

## INTRODUCTION

Classroom management is a primary goal in many schools. If children cannot attend to academic lessons and cooperate with one another, it is difficult if not impossible to achieve the educational goals for the day. However, in schools particularly designed to support children with behavior challenges, classroom and behavior management become even more central [8]. A typical behavioral modification strategy for children involves raising awareness of their

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**Figure 1: The Patrol Chart: an example behavioral chart; Each student is a row, and each square in the row corresponds to red, yellow, or blue which is high, medium, or low achieving.**

positive and negative behaviors over some recent period of time, usually during the last hour, day or week. Enabling reflection on behavioral patterns can help children to understand their own triggers, develop positive behavior strategies, and communicate the inner states that are leading to their negative behaviors. Visual cues can improve communication for children with ASD [2], ADHD, and other social and behavioral challenges, particularly in relation to behavior management [1].

To this end, teachers and behavior specialists employ a variety of visual supports to reflect the behavior of their students and encourage positive behaviors [12, 6]. These visual displays increase awareness of individual behavior by visualizing behavioral performance (see Figure 1). These tools, however, are not in use in a vacuum. Careful planning of activities, direction of school staff to view the displays, and updating of the displays based on recent behavior all come together with rewards and reinforcement to form a comprehensive behavioral program. Thus, we were interested in developing technological supports that could be integrated into this existing structure.

Although existing visual tools generally work well, they are often geared towards individual goals with little regard for group interactions in a classroom. Additionally, even digital tools used for behavior management—both tablet-based individual displays and large-screen classroom displays—

tend to be fairly static representations of individual performance that do not fully engage students. Thus, in this work, we were interested in understanding how technologies, in this case situated displays, might both engage students at a classroom level and encourage them to think more abstractly about behavioral performance.

The results of this work make three contributions. First, we demonstrate that classroom displays focused on collective behavioral performance can support reflection on individual performance and improve behavior for students with severe behavioral challenges. Second, we demonstrate that these collective displays encourage cooperative behavior in behaviorally challenged classrooms. Third, these results indicate a variety of issues that must be considered when designing for these environments, including representing ambiguity and failure as well as the relationship of novelty to engagement with technologies in schools.

### RELATED WORK

Visual supports use “words, pictures, photographs, icons, actual objects” [9, 12] in both digital [6] and paper-based displays to support awareness of tasks, behavior, and other classroom concerns. In particular, token-based rewards systems [8] often use visual aids to motivate and reward appropriate behavior [12]. Visual supports can provide consistency and structure to reduce anxiety and support better self-organization around time for students [12].

Research in pervasive computing explores the use of interactive displays to augment existing visual supports in the classroom (such as vSked [7, 9]), and outside (such as MOSOCO [4] and MoCoToS [6]). In particular, interactive visual supports have been shown to help children with autism remediate their speech and language disabilities [10, 13], provide feedback on their pronunciation [5, 9], reduce the quantity of educator-initiated prompts [4, 7], encourage consistency [7], and enable skills generalization in real life situations [4]. These studies demonstrate a great potential to use novel technologies to support behavior management at the individual level in special education classrooms. However, there are still open questions as to how the benefits students gain when using interactive visual supports could also be used to promote reflection and help students reason about their success or failure in achieving a proposed behavior at a collective level.

Our work also builds on research focused on behavior change outside of special education. For example, ubicomp research has explored how ambient and persuasive situated displays induce behavior change and increase wellbeing. In particular, visualizations of activities and behavior patterns can promote reflection at an individual level, encouraging healthy habits, like dieting and exercising (such as Ubifit [3]) or at a collective level, such as at the workplace (for instance [11]). Our research builds on this body of work by focusing on how situated displays could support positive behavior in schools at the individual and collective level.

### METHODS, SYSTEM, AND STUDY CONTEXT

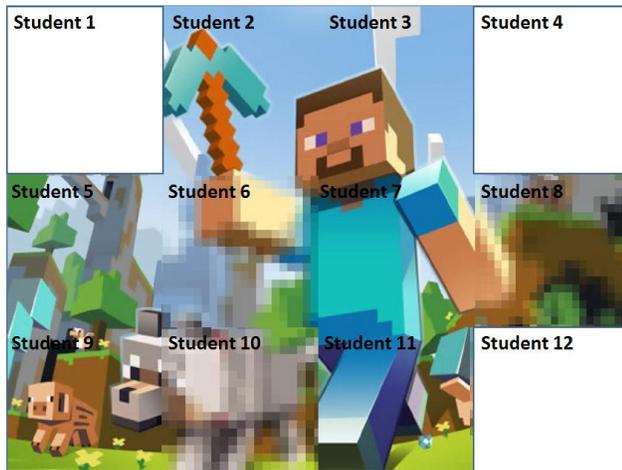
We evaluated the potential for a classroom-based collective display to stimulate both individual and cooperative positive behavior through the deployment of a puzzle-based collective task in two classrooms across four weeks, with two weeks of baseline data collection and two weeks of intervention. As an initial study in a school that supports a particularly vulnerable population, this duration was appropriate for demonstrating the feasibility of this approach, its potential effectiveness, and key design considerations for future iterations of such displays. However, the lack of a control group and somewhat short duration prohibit us making strong statistical claims regarding the impact on the children’s behavior. In this section, we describe the deployment study, including our data collection and analysis approaches.

#### Site

This study was conducted in a specialized public school for children with behavioral disorders associated with a national research center focused on neurodevelopmental disorders. Established in 1982, the school has four classrooms serving approximately 60 students aged 6 to 12 year-round. The school delivers a standard public school curriculum, supplemented by daily group cognitive-behavioral intervention, behavior support, and clinical case management as well as weekly parent support group.

The school’s behavior modification strategies include a variety of approaches but are heavily token-based [4], meaning that students can earn points and rewards for appropriate behavior. Up to twenty points can be earned per thirty-minute time slot called a “center”. Behavioral specialists manually determine the number of points each child earns assessing behavior through direct-observation. Problematic behavior does not reduce points already earned but can result in a *time-out*, in which no points can be earned for a specified time period.

A paper-based classroom display called the *patrol chart*, shows student performance during each center i.e. a 30-minute chunk of time (see Figure 1). At the end of each center, behavior specialists place a colored square representing performance in terms of percentage of available points earned: blue to underperforming students who earned less than 70% of possible points, yellow to students who earned between 70% and 90%, and red to students who earned more than 90%. The name of the chart originates from the concept of “patrol”, which is free time at the end of the day. The activities that may be undertaken by any individual student during this time are determined by their behavior performance for the day. At the end of the week, the students view cumulative graphs of their performance over the week, again expressed in percentage of possible points using the three colors, and are again rewarded accordingly.



**Figure 2:** The puzzle uncovered at the end of the day (students 1, 4, and 12 underperformed; the performance of the students 6, 8, 10 was at average; students 2, 3, 5, 7, 9, 11 performed well)

### The Design of the Puzzle Display

We co-developed the puzzle display used in this study with teachers and behavior specialists from the school in which we ultimately deployed it. Design sessions, team meetings, and interviews ultimately led to the creation of a shared “public” display for use within the classroom. School staff were particularly eager to take this approach, because they already use large displays in their classrooms to capture the attention of their students and find it challenging to do so with paper-based tools. These sessions also revealed the importance of refreshing the content (such as images behind the puzzles) and varying the display over time. Such changes are considerably facilitated through the use of technology, as paper-based tools are difficult to personalize and maintain. When possible, this kind of maintenance with existing tools requires substantial effort on the part of staff to make and remake the paper-based tools regularly. Thus, we designed our system to allow for adaptation in students (names, number of students, and so on) as well as in puzzle content quickly and easily each day.

### Cooperative Puzzle Intervention

We created a classroom display with a puzzle metaphor to encourage positive behavior in students at both the individual and collective level. Each puzzle piece corresponds to an individual student. At the end of each day of the intervention, teachers revealed the pieces corresponding to behavioral performance: good behavioral performance (>90% points or “red”) earned a clearly drawn piece; underperformance (<70% points or “blue”) remained white; in between performance (“yellow”) earned a pixelated image (see Figure 1 for colored paper version and Figure 5 for our puzzle display prototype).

The puzzle was built based on the classroom economy that was already in place at the school. When group behavioral performance reached a certain threshold (85% or more of students earning more than 90% of available points or

“red”), all students, regardless of individual behavior, received a printed card of the completed picture, which they could “cash-in” for fifty “school bucks”, a specific currency used to buy treats from the school store. Additional criteria for receiving the reward included no more than two yellow and no blue marks per classroom for the day. However, during the intervention, the staff also adapted this threshold day by day according to the subjectively assessed collective effort in achieving positive behavioral performance. Each day, staff members from each classroom selected the images to be displayed. These images included popular movie and game characters as well as current academic topics (such as the respiratory system).

### Experimental Design

28 students, ages 8 to 12, across two classrooms participated in the intervention for two weeks. Of those students, the parents of 15 (9 students from one classroom and 6 from the other one) agreed for them to participate in interviews and to have their behavioral records from the school accessed for analysis. Due to the emphasis on behavior management for the students in this school, classroom staff uses direct observation annotating detailed records of student behavior, assessing each student every thirty minutes in a regular school day (from approximately 9AM until 2PM). These records include: i) the number of points collected during the first and the second daily social skills class sessions (SS1 and SS2 in Figure 4), ii) the number of points collected during all academic classes in the school day, iii) the number of points collected during out of academic class time, iv) the total daily points, and v) the number of time-outs, a negative reinforcer for particularly poor behavior.

To evaluate the effects of the puzzle intervention, we compared the records of behavioral data collected during the intervention with the ones for two weeks prior to the study (baseline). The staff reported that there were no changes in the educational program during the intervention beyond introduction of the puzzle display nor were there any external factors likely to have affected behavior. This school regularly uses the same public screens that we used to display the puzzle intervention. During baseline, they used these screens to display video games, educational movies and behavioral information; thus, this technology itself was not particularly novel to children.

### Interviews

At the end of the study, two members of the research team conducted structured individual interviews with the 15 children whose parents consented for them to participate. These interviews lasted approximately 15 minutes each, which is approximately as long as a child with behavioral challenges of this age can tolerate sustained communicative engagement. Additionally, we interviewed each member of the staff who participated in this study, including two teachers and four behavioral specialists. These interviews were individual and semi-structured and also lasted around

15 minutes, because they were conducted during breaks, which are time limited. Interviewees were encouraged to discuss their experience in this study, the motivational drivers for the puzzle to be accomplished, the comparison with the current visualizations at their school, the concept and the rules of the puzzle, and related topics. All interviews were audio recorded and transcribed for analysis.

**Analysis**

The records that contain student’s behavioral assessments, the field notes taken by the researchers during the study, and the interviews were analyzed together using a mixed-methods approach. Various categories of the behavioral performance were compared using t-tests for the baseline and intervention periods. In particular, we compared the behavioral performance at both the individual and collective level, analyzing the performance of the whole group. At the individual level, for each student separately we analyzed the available behavioral data during the intervention and compared it with the behavioral performance during baseline. In each phase, these data included eight school days over two weeks, for a total of 16 school days over 4 weeks. At the collective level, we analyzed the behavioral reports for all the students together and compared the mean values of each behavioral parameter (described in Experimental Design) that has been assessed during each phase.

**RESULTS**

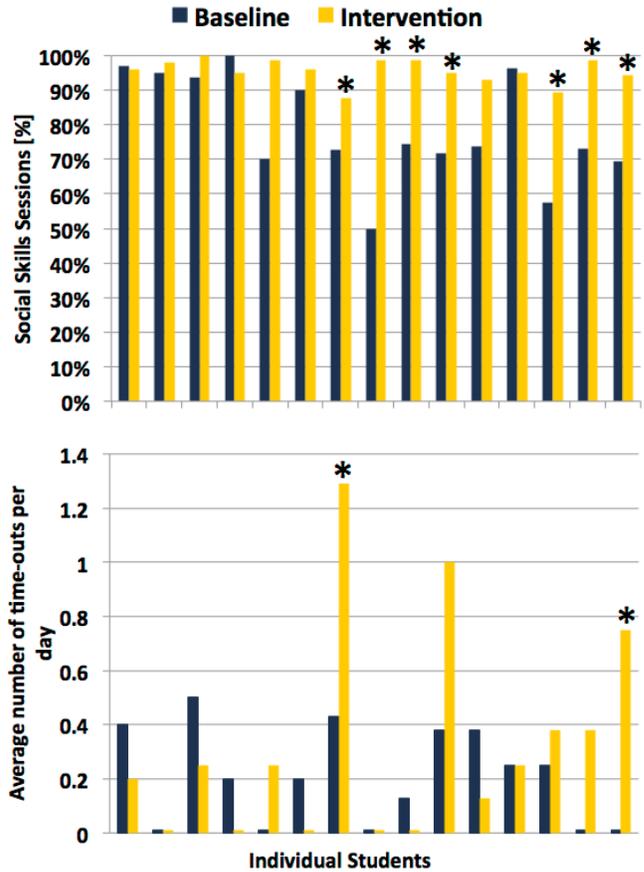
We examined responses to and the impact of use of the cooperative puzzle display in terms of engagement with and attention to the display to support individual behavioral performance and classroom-level cooperative efforts. We also analyzed the acceptance of a collective behavioral display, its adoption by both students and staff, and the potential for using it as a standard part of educational programs for children with behavioral challenges.

**Individual Behavior Support**

One of the primary concerns raised by educators and behavioral specialists at the school while designing our display was the potential impact on individual behavioral performance in a negative way. In particular, staff voiced concerns about “free riding” in which students might not try to perform well, knowing that they could potentially still earn the group reward based on their classmates’ behaviors. In practice, however, we saw very little of this kind of behavior. During the deployment, the staff described no incidences of such behavior and no major patterns of significantly worse behavior were identified from the records when comparing their behavior at the individual level during each phase. Specifically, no student earned significantly fewer points during any *center* during the deployment than before.

Overall, seven out of the fifteen students (for whom we were granted with the access to the behavioral records) demonstrated statistically significant improved behavior

during one class in particular (social skills, non-academic) when using the cooperative puzzle display (Figure 3 top:  $p < 0.05$ ). For two students, the overall daily performance



**Figure 3: Student behavioral performance before and during the intervention at individual level (statistically significant differences are denoted with asterisk; behavioral performance during social skill sessions is expressed as percentage of available points; the average number of time-outs are expressed per day, e.g. 0.2 refers to one time-out in five days)**

was significantly better ( $p < 0.05$ ). There were no statistically significant differences found for behavioral points earned during other classes at the individual level.

Despite the improvements observed for most students, particularly during social skills, the number of time outs for inappropriate behavior actually increased for two students ( $p < 0.05$ ) (Figure 3 bottom). Although this negative reinforcement is explicitly designed to impact earned points—it is a “time out” from earning points—the increased time outs did not affect any other behavioral parameters in these two students. Additionally, no other students showed significant differences in timeouts (Figure 3 bottom). Comments during the interviews from both the teaching staff and the students indicate that they perceived an effect on behavioral performance:

*B1<sup>1</sup>: I think that this definitely shows that it was effective and especially this week there was no kid who earned yellow, so there has to be something. This is really good that every single kid earned red.*

*S2: I would say that it [the puzzle display] is good. It's better because I've been getting more reds!*

The impact of the display on behavioral performance may be due to a variety of factors. We used the interviews with staff and students to begin to unpack the ways in which the display interacted with their educational program and behavioral performance. We discovered that integration with the existing motivation and reinforcement systems as well as the introduction of something novel and interesting were both key drivers in the children's acceptance of the display, which are the aspects discussed in the following.

#### *Integration into Existing Structures*

Classroom displays, both digital and paper-based, are already in use at the school to present relevant educational materials as well as to report on the behavioral performance of each individual student, as described in the Background section. Our display, like these other visual displays, was intended to increase awareness of behavioral performance as part of the existing rewards and reinforcement structure. The combination of rewards, a printed card and fifty "school bucks," proved powerful for the students, who described wanting "school bucks" regularly in their interviews.

*T2: Kids invested in it. Price of 50 [school] bucks was big for them.*

The monetary reward, as attractive as it was, however, is not likely to be the entire source of the motivation for these students. They collect "bucks" for a wide variety of positive behaviors, including reports from home, and by the end of the school year, when this study took place have often earned more than they can spend.

*T1: The reward of 50 [school] bucks is fine, but I think that the visual aspect was something that had the greatest effect. You give them a hint in the morning, and then their behavior was better during the day. At end of the year, they already have a lot of money, but it was the visual that was the kicker.*

The students, however, perceived small differences in their ability to earn this credit due to the puzzle being revealed only at the end of the day as opposed to every thirty minutes as is the case with other individual measures.

*S7: It was different. It is a little bit harder with the puzzle piece, because you only have one chance. With the charts,*

*you have a bunch of the centers so you can turn it around. [The puzzle] makes you work harder and stay on the task more.*

In actuality, it is the percentage performance at the end of the day across all of the centers that determines what puzzle piece each student receives at the end of the day based on behavioral performance. However, the perception that it happened only once per day may have contributed to some students working harder or perceiving that the task was more difficult.

#### *Excitement Related to the Use of Technology*

As we expected, the students enrolled in this study showed substantial interest in the collaborative situated display. In an era when children are inundated with multimedia experiences outside the classroom, it is perhaps unsurprising that students showed such positive reactions and excitement towards the display. Teachers and behavior specialists reported this inherent attraction that digital technologies have for the students, noting that the display naturally drew their attention in a way that other visual supports often did not.

*T2: It's great because kids love technology! Nowadays they play video games, etc. and anything on there [the large screen] they are immediately drawn to.*

However, positive comments about the inherent draw of screen-based technologies were often followed with the caveat that the tools must be used "appropriately," typically meaning in a way that supports the academic and behavioral goals of the school.

*B1: The technology spikes the kids' interest... They like it. It intrigues the kids. It is good when appropriately used.*

Of course, just having a large screen in the classroom is nothing new for many students, and in particular, in this school, they were already regularly using large screens to display as previously described. Therefore, the mere use of a large screen was not expected to have a considerable impact on the children's behavior, rather the system had to provide something more for the students beyond this initial flash of technology. In the case of the puzzle display, the visualization was seen to be particularly motivating by the students and a means for learning about their behaviors by the staff, even without the students' knowledge.

*T1: It [technology] improves the education – maybe they do not realize that they are learning but they are.*

To draw student attention to the display, the teachers created a new practice by which they revealed a single blurry piece in the morning. During our observations, the students typically immediately began guessing the content of the picture, trying to get hints from the teachers and behavior specialists, and competing with their classmates about who might know the picture's content.

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<sup>1</sup> Names of all participants have been replaced by a letter number code; the letter represents type of participant. B=behavioral specialist, T=teacher, and S=student.

*S3: I like being curious. For instance when they uncover only one piece, I like when they do that.*

*S8: I like [the puzzle] in the morning it gives me something like “oooh what is on the picture?” I want to know it. And then at the end I know it. I think this is a good thing.*

This curiosity stayed with them throughout the day, ending with the culmination of the picture’s reveal (or lack thereof on days that the students did not earn their privileges). The teachers and behavior specialists developed practices around this celebratory reveal at the end of the day that highlighted both the team aspects and the individual contributions of the students. In particular, after viewing our early designs, they requested names to be added to each puzzle piece indicating whose responsibility each segment of the image was.

*T2: The fact that their name was on each piece did show them that they have the ownership over it! We were initially discussing that, to put it or not, but at the end it was a right decision, they all worked together and the piece helped them to know “that’s me, I worked for this piece”.*

Our observations confirmed this perception of individual responsibility. For example, one afternoon following the reveal of the image, a student proclaimed: “*I discovered his [character’s] head*” with another answering “*I discovered his arm.*” This public claim of responsibility demonstrates confidence and pride in a population of students often plagued with self-confidence issues.

Using the technology to attract students’ initial attention proved to be an effective strategy in our study. However, maintaining student attention required an adequate follow up by the educators who managed to use their curiosity to motivate positive behavior. These results confirm our initial belief that novel display technologies in classrooms must be integrated with educational structures and practices, including the ability to identify individual contributions clearly within collective tasks, a key issue for assessment in elementary education.

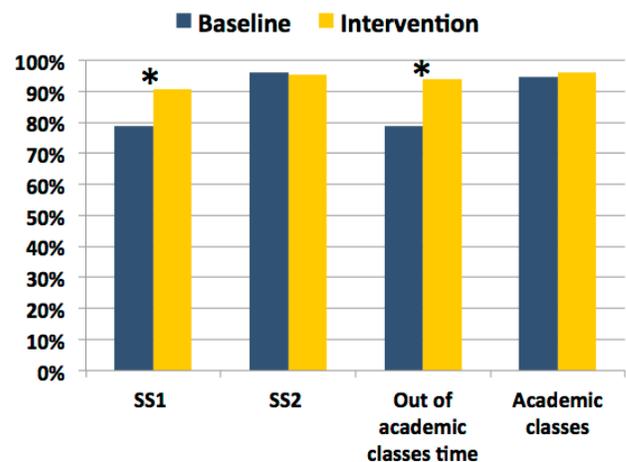
### Collective Behavioral Support

Encouraging socialization, team effort, and collective responsibility can be challenging in any school, but children with autism and ADHD—the students in this school—may have even greater difficulties in these skills. Teachers and behavioral specialists described these challenges in their classrooms, including the inability to compromise, hear other people’s viewpoints, act as a team, and so on.

*B2: Teaching kids to act as a team is difficult for both neurotypical kids and the ones with mental problems. It is difficult for them, because they are young and immature to understand how working together can actually accomplish something.*

*B1: Social awareness is an issue especially with autistic children; group rewards are challenging for them to understand.*

One of the important research questions for us was whether a display powered by their group interactions could support this kind of collective thinking and cooperative effort. Collectively, the students demonstrated a significant improvement in the behavioral performance during the first daily social skills session, achieving on average 18.15 points (out of 20) during the intervention as opposed to 15.79 points during baseline ( $t= 1.83, df=14, p<0.1$ ) (see Figure 4; the scores are represented as percentages of the maximal number of points). On the other hand, their behavior was not significantly different in the second daily social skills session. This difference may in part stem from timing: the first daily social session is typically organized in the morning when the memory of the puzzle is still fresh (as the puzzle was always discussed in the morning), unlike the second social skills session in the afternoon.



**Figure 4: Differences in the students' behavioral performance before and during the intervention at collective level (performance is expressed as percentage of available points; statistically significant differences are denoted with \*)**

Given the short duration of the study we did not necessarily expect to find statistically significant changes in children’s behavior between the baseline and intervention phases. However, students demonstrated statistically significant improved behavioral performance outside of academic class time, namely 54.99 points at average (out of 60) during the intervention as opposed to 47.20 points during baseline ( $t=2.51, df=14, p<0.05$ ). On the other hand, no significant differences were found either in the students’ behavioral scores during academic classes, daily total scores (see Figure 4) or in the number of time-outs.

This result was somewhat surprising, because the display was not visible to the students outside the classroom. However, one behavior specialist offered an explanation for improved outside behavior—without actually seeing our quantitative analysis, which had not been completed at the

time of the interviews—essentially arguing that inside behavior might suffer from ceiling effects.

*B1: The puzzle game encouraged the cooperative effort, especially outside. In the classroom they are already pretty good.*

Additionally, the staff described our intervention as “reinforcing”, “beneficial”, and “a reminder for students to work together”.

*B2: They were looking at it at the end saying “hey we got it”. I did not hear anything negative at all. It was a good reinforcement for the kids!*

These results indicate that such systems can be used to impact behavioral performance. Additionally, the qualitative results shed light on the underlying mechanisms by which such a display seems to work, including the creation of new structures and routines around a collective artifact and the potential for social engagement and support through this kind of cooperative technology.

#### *Creation of New Cooperative Structures and Routines*

Building and maintaining routines is one of the key components of well-managed classrooms for children with behavioral problems [7]. Thus, as noted in the previous section, we had intentionally designed the system to work with the rewards structure already in place.

*B3: I think that it compares with the stuff we do here – reinforcement, but it also has a group reinforcement, which is the aspect I liked.*

However, the addition of a new artifact, particularly one that is radically different in some ways, also engenders the potential to create new practices. As part of this exploratory study, we left such efforts in the hands and control of the teachers and behavior specialists at the school, who began to experiment with their own structures and policies in response to the new capabilities of the display. For example, they established the stable routine of discussing the puzzle at the beginning of classes, as evidenced by the directions T2 provided one morning:

*Every puzzle piece will remain white if you don't perform well, it will be blurry if you have a yellow day and it will be crystal clear if you have a red day... But can we see the whole image if we just have some crystal pieces? No, so we need all of you to be great!*

At this time, they showed one blurry piece of the puzzle. They then reminded the students about the puzzle verbally just before lunch and revealed the pieces earned throughout the day at dismissal. These practices resulted in the children's immediate comprehension of the need to “work together,” with one student declaring during our observations: *We all have our puzzle piece, and if we are really good it will be clear at the end of the day... We have to work on this together... And we will all get the coupons [school bucks]!*

Once they had done the work of integrating the system into their curriculum, all of the teachers and behavior specialists described wanting it to stay there as part of the “standard” program, even wondering why it was “*not already part of the education!*” (B2). Their enthusiasm for the tool's integration also expanded beyond their own specialized school into the regular public school curriculum:

*B1: For sure it can be part of the standard educational program, and definitely here. Group reward is something that our students can benefit from as many of them have peer issues. Also, for the normal public schools it is easy to implement and cheap since a lot of schools have problems with resources.*

Based on our observations and the interviews, the puzzle quickly became an integral part of the educational routine at the school and was well understood and accepted by the students. These results indicate that even novel technologies that might be distractors for students can support existing pedagogical approaches when appropriately integrated. Additionally, empowering school staff to perform this integration can improve adoption and generate creative new strategies and pedagogical approaches.

#### *Social Engagement*

For children with autism and ADHD, learning social skills can be particularly challenging. For many of the students at our field site, their behavioral challenges stem from “peer issues” making social skills a key element to the curriculum. Cooperative tasks and shared displays can provide the kind of common ground and shared interests needed to facilitate social engagement for this population.

*B1: They talked about it, about pictures, they were guessing the picture, and at the end having the picture in their hand. It stimulated the friendships among them.*

Beyond just having something to talk with each other about, however, a shared display can also facilitate teamwork and create a kind of group atmosphere, which was one of the main objectives of this study. Teachers and behavior specialists alike described their students as being willing and able to work as a team, something that they had doubted to some degree in early discussions during the planning stages of this study.

*T1: ... it made my students more aware to be team players. I've seen more of a comraderie among the students. They understood the link between individual and group benefits. Also they exhibit the sense of responsibility for the team.*

*B2: They really tried to work as a team. I think that if someone did not earn it, this impacted them as a whole.*

The students likewise reported reaching out to other students who were not their friends. In particular, they often engaged students who were alone or not participating in some kind of social activity, thereby improving the behavioral performance of both the inviter and the invitee.

*S7: I am giving people more nice sayings, and I am helping them to play the games that people say that they cannot play, and I am also playing with them more often.*

These effects could be due to a variety of factors, including the impact the display may have had on the staff members themselves. We had worried that more attention might be paid to group activities and socialization by the teaching staff, because the presence of the display placed these issues in the forefront of the minds of the classroom staff. However, in our observations, we did not see extensive discussion of the display nor of the need for teamwork, echoed by sentiments of the behavioral staff during interviews:

*B3: It was group cooperation! It was just a sort of an umbrella that they could look back or remember during the day. We did not remind them constantly, but it is just something that makes your decisions throughout a day affect the outcome if you get this and whether or not everyone else gets it.*

The students immediately recognized the team nature of their interactions with the display, often mentioning team sports:

*S5: We have to work together to earn the puzzle piece. It's like in soccer...*

*S1: It's fun, you get to earn something, and we get to work as a team to earn it.*

Just as in team sports, the feelings related to the cooperative effort were not always positive. Almost every student reported feelings of being sad or embarrassed on the occasions when they underperformed compared to the rest of the group. Prior to the puzzle display, this kind of comparison was even easier, with every student's precise individual behavioral performance prominently displayed. However, the connection of this individual behavior to a group reward and to group performance was new and likely contributed to these greater expressions of dismay at poor performance.

Before beginning the deployment, the staff expressed concerns related to the possibility of good performers mistreating the students who did not contribute enough. However, we did not see any of this kind of negative behavior during the deployment itself, a finding echoed by teacher and student reports.

*T2: My concern was that they would start being upset with the kids that earned less than red and for the ones that were not helping out the group – I didn't see it in the classroom.*

*S9: We have to work together, and it's just that one person doesn't have to feel bad because they were the only one that didn't get it.*

It's not that the high performers were not paying attention or concerned about the low performers. It is just that they responded positively, trying to encourage them to improve.

*B3: Especially for the kids that started bad in the morning, the others warned them that they still have a chance to help out the group and themselves. And in this case, by helping themselves they were helping out the whole group.*

Moreover, in such encouragements the students mimicked the behavior of classroom staff. Specifically, a regularly taught lesson at the school is that there is always another opportunity to perform well, and students described telling their underperforming friends “*just try next time and we can do it!*” (S6) or “*there is always tomorrow and we can still make it!*” (S4). This idea of looking to the future is heavily emphasized in the school in general and was seen by the staff as a positive response to disappointment.

Of course, the students could sometimes go a bit far in their directions, giving quite specific commands to other students. For example, in response to an interviewer question about what he might do the day after his class did not earn their puzzle, one student described the specific steps he would want his classmates to take and went so far as to finish the interviewer's statement with a proclamation of his intentions to take control:

*S12: ...tell my friends in my classroom next time to work on raising your hand, not calling out and don't get that much timeouts.*

*Interviewer: So you would want to tell your friends-*

*S12: what to do.*

Additionally, although the vast majority of students were supportive and reported the display as “fair,” not everyone agreed. Anyone who has spent much time with an elementary school child is acutely aware that they are developing their notions of fairness in response to a wide variety of stimuli in their worlds. For children with autism and ADHD, this issue can become even more acute. Thus, it was no surprise that teachers and behavior specialists voiced concerns about the potential for students to respond negatively to the displays depending on their perceptions of fairness with regard to the group rewards. A few students described frustration and anger when discussing scenarios in which they had performed well (earned “red”) but the class had not (earned “yellow”).

*S12: [The display] makes a big difference. It makes a big difference, because I can, having the whole class earn it and if they don't earn it, I'm bummed, but if they earned it but they didn't earn it, they earned it in general, but they didn't earn it in reality, that wouldn't be fair, really.*

No students described their peers being angry with them in the reverse situation, however.

Balancing group encouragement and peer support with notions of bossiness and hostility can be a particular challenge in classrooms. In this school, students are regularly encouraged to “focus on themselves” first so as to avoid confrontations over other students' behavior. However, this advice, as useful as it is at controlling

individual behavior, can leave students ill-equipped to transition back into regular education schools that do not have such behavioral supports in place. Thus, a tool like the puzzle display can help bridge the gap between totally individualized and totally collective behavior.

### Designing for Behavioral Support in Classrooms

We describe several aspects that arose from our experience in this study, which should be considered by the designers of similar educational tools. In particular, considering how to represent ambiguity in a rules-based rewards system and how to support production of failure for teachable moments emerged as unexpected needs in this work. Additionally, considerations for sustaining interest in these types of tools over extended time are important for any system but became particularly apparent in this work.

#### *Ambiguity*

For children with special needs, in particular autism and ADHD, clear rules and consequences are essential to supporting behavioral interventions. The puzzle display was built on a set of mathematical rules related to a behavior monitoring points system already in use. However, the students did not always understand the calculations underlying the display.

At the group level, a certain percentage of students (85% of those in attendance on a given day) each had to perform at a high level (90% of available points for that day) and no more than two students in class could earn “yellow” (70 to 90%) and none could earn “blue” (<70%) to earn the group reward. Percentages are of course tightly tied to the number of students present for the day and the number of activities engaged in which the students could earn points. This kind of logic was clear to the behavioral specialists. However, given that math standards in the United States do not teach percentages until 6<sup>th</sup> or 7<sup>th</sup> grade, and the highest grade in our study was 5<sup>th</sup>, this approach could be deeply confusing to the students. For example, one student described a day in which they had not earned their group privileges as seeming exactly the same to him as another day in which they did.

*S11: ... another day we had two yellows and they said it was, they said okay, and on this day we had two yellows and we didn't make it.*

In S11's example, the same number of students performed poorly, but fewer students were in attendance on the day in which they did not earn privileges, lowering the percentage.

Interestingly, this use of percentages is tightly engrained in the way in which individual performance is currently tracked at the school, leading us to incorporate it in our display without question. However, this mismatch between the students' cognitive understanding of how their behavior is reported and their performance based on these reports bears additional research. In particular, it is remarkable that the existing behavioral system works so well, and that the students profess to understand it completely, reporting in

interviews that they know exactly how to “earn red” even if they are not always successful.

As an additional point of ambiguity, the connection between individual points earned and the reveal of the puzzle piece for each student at the end of the day became challenging for some students. The puzzle display had only three levels: white, blurry, and clear. In contrast, the more individual displays traditionally in use in the classrooms showed individual performance at a much more fine-grained level. Thus, students expressed frustration at not knowing how close they had come to the next level.

These results indicate that ambiguity in the design of classroom systems can be challenging for students. It can also be a way to allow the students to play with their own understanding of the rules of the classroom—not unlike adolescent testing of boundaries of societal rules—and may even have benefits in terms of teaching them to adapt to a world that sometimes seems unfair.

#### *Failure as a Teaching Tool*

As already reported, during the deployment study, the students performed admirably, both as individuals and collectively. However, teachers and behavior specialists noted that failing to accomplish a task can also be a key component to a behavioral intervention plan.

*T2: I am glad that was one day that they did not earn the puzzle piece because they were earning it several days in a row. So it was good to see that there is a difference in the [puzzle]. The day after that day, I think I saw more effort overall throughout the classroom, and they tried to pump each other up. One student had a tough day, and he thought that he could not earn red, and the other kids were all pumping him up saying that he has to have positive thoughts, etc. They were laying on nice sayings to this student, and it was really cool to hear that!*

This focus on teachable moments and failures, alongside the positive performance of the students, indicate that making the challenges more difficult may be in order, particularly for older and more advanced students.

*B2: The same concept can be applied also for the older kids but it should be harder for them.*

Classroom staff suggested how to make the puzzle completion task more challenging. For example, some suggested linking each puzzle piece to only the behavior found to be most difficult or in need of intervention for each individual student. Both students and staff also suggested making the pictures more difficult to guess, thereby increasing the excitement and reward of learning the display's content at the end of the day. Based on these results, we developed a new system that supports greater personalization and adaptation by teachers (see Figure 5)



**Figure 5: Developed prototype as a follow-up implementation of our design concept. A teacher can upload new puzzle images (top), override behavioral performance (middle) and configure the refreshing period of the display (bottom)**

### *Sustaining Interest*

The introduction of novel technologies has been known to garner substantial interest briefly that then wanes over time. Classrooms are no exception to this rule, as evidenced by muted response to the large screen displays already present in the school classrooms at our site. Likewise, two weeks in a school is not enough time to measure sustained engagement. However, the results of our deployment study indicate some strategies that are already in use and could be adapted to encourage this kind of long-term attention and impact.

First, the system itself can be refreshed to remain engaging to the students. One sees this clearly in the ways in which paper-based bulletin boards are used in elementary education currently. During our deployment, some of this positive effect was already in evidence through the responses to the changing of the images daily.

*T2: The puzzle itself was interesting for them and novel. This is because they had a different picture everyday!*

Second, teachers might bring this kind of tool in as a refresher from time to time when the students are particularly struggling with team-based behaviors.

*T2: I would bring it for a few days and then remove it so that they are not getting used to it every day and it remains fresh and exciting... It would be used for instance also when I think that there will be a tough day for them or a tough week, so I would help them out with this game.*

The benefit of a digital display of course is that it can be tied to any number of behavioral measures. Thus, this kind of display would not be limited to only the cooperative measures used in this study but could expand or be repurposed for a variety of other behavioral visualizations.

Finally, the rewards structure surrounding the use of the system could also be adjusted to ensure sustained interest.

*B1: Maybe also the rewards could be changed, such as a group party. Or for instance to make random rewards, so that they don't know what it is just like they don't know what the picture is going to be.*

*T1...they seem to enjoy the ticket but if we could link it to something more unique rather than money or snacks. We can make a unique prize, a unique reward.*

These results indicate that while a classroom display may in itself be compelling, and even more so when the content regularly changes, the novelty of such a system may also wear off over time. Thus, using a variety of strategies, both through the design itself and in the practices surrounding the design, to maintain attention and excitement are necessary for long-term use.

### **CONCLUSIONS AND FUTURE WORK**

This paper presented the findings from a deployment study of a classroom display to encourage positive behavior and team effort in students with severe behavioral challenges. In addition to our primary objective of evaluating the impact of the puzzle on the students' behavioral performance and cooperative behavior, we aimed to understand both the issues and opportunities for designing the tools that can improve student understanding of the link between individual and collective behavior. Results indicate that classroom displays that represent a collective task can simultaneously increase awareness of individual performance and stimulate positive behavior at both individual and collective levels.

The results of this study also provide important insights into a set of factors to be considered when designing the educational tools for behaviorally challenged classrooms. In particular, designers must consider integration within the standard educational structures as well as the creation of new structures around these technologies. Likewise, designs must include the potential for representation of ambiguity and failure as educational strategies and the potential for maintaining interest over the long term.

Standard educational programs, particularly for children with special needs, tend to be structured in a person centric way and focused on individual tasks and assessments without much regard for the cooperation in a classroom and the team level performance. This approach, though highly effective in many ways, can be an obstacle for their integration into regular educational environments. Novel educational technologies, like our puzzle display, can stimulate cooperative work while including reminders of individual behavior and individual contributions to team goals. In turn, increased awareness in students can lead towards an improved understanding of the notion of cooperative behavior. This work is an enabling step towards reaching these goals and motivating further development and research around educational tools for stimulating positive behavior and teaching cooperative skills.

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