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Tablet-Based Activity Schedule for Children with Autism in Mainstream Environment

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ABSTRACT

Including children with Autism Spectrum Disorders (ASD) in mainstreamed environments creates a need for new interventions whose efficacy must be assessed in situ.

This paper presents a tablet-based application for activity schedules that has been designed following a participatory design approach involving mainstream teachers, special-education teachers and school aides. This applications addresses two domains of activities: classroom routines and verbal communications.

We assessed the efficiency of our application with a study involving 10 children with ASD in mainstream inclusion (5 children are equipped and 5 are not equipped). We show that (1) the use of the application is rapidly self-initiated (after two months for almost all the participants) and that (2) the tablet-supported routines are differently executed over time according to the activity domain conditions. Importantly, compared to the control children, the equipped children exhibited more classroom and communication routines correctly performed after three month of intervention.

ACM Classification Keywords

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

Author Keywords

Autism; tablet application; activity schedules; participatory design; educative inclusion in mainstreamed environment; idiosyncratic multimedia contents.

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INTRODUCTION

There is growing evidence that educational inclusion produces a positive effect on children with Autism Spectrum Disorders (ASD) [14]. Yet, inclusive education of these students is often hampered by the misgivings of school staff that presumes negative outcomes on classroom functioning if the student is not autonomous enough to perform a range of tasks [10]. Specifically, children with ASD may need help to manage daily routines, make transitions between activities and engage in social interactions [4]. If these special needs are not addressed, they can result in interruptions during class that decrease learning opportunities, not only for the student with ASD, but also for all the students [19].

Activity schedules are an efficient method to enable children with ASD to be more autonomous [15, 16, 18]. An activity schedule is based on picture and/or text sequences decomposing tasks or activities into successive steps [18]. By following such schedules, users can achieve tasks, using paper-based supports [15] and multitouch tablets [3, 12]. Hence, activity schedule is a promising assistive method, especially when it is realized on a tablet, because of the documented preference of ASD children for this device [21, 22].

Surprisingly, the use of computer-based activity schedules in school settings is only proposed for special classrooms, not in mainstreamed classrooms. This situation may stem from the complexity of specifying tasks that need support in general classroom, compared to special classroom. For instance, contrary to special education settings, inclusive education in a secondary school entails frequent changes in terms of classrooms, teachers, and classmates. Furthermore, in mainstreamed environments, the expectations of teacher may not be as personalized as in a special classroom. For instance, a pedagogical focus on a single task or a limited set of tasks is possible in a protected class, whereas a wide panel of tasks is implicitly expected as being correctly performed in mainstreamed setting.

In this paper, our contributions are as follows:

1) the creation of a tablet-based application, named *Classroom Schedule+ (CS+)*, that implements activity schedules. This application has been designed following a participatory design approach involving mainstream teachers, special-education teachers and schools aids. In doing so, we identified activities that must be supported in general classrooms for students with ASD, and we collected the requirements needed for a computer-based activity-schedule system. *CS+* supports two domains of classroom activities for which mainstream teachers have given priority: classroom routines and verbal communication.

2) the deployment of this application in general inclusive classrooms in a user study. We demonstrated the efficiency of our application with 10 students between the ages of 13 and 17 that were in an inclusion program for the first time at a secondary school (one hour per week accompanied by a school aide). Specifically, five students with moderate ASD were equipped with CS+ (ASD experimental group), while five others students with moderate ASD were not equipped (ASD control group).

RELATED WORK

Assistive technologies in school context

Several computer-based intervention tools have been developed to support inclusion in mainstreamed environments. For example, Escobedo et al. provide a smartphone-based tool for practicing social skills during breaks, using an augmented reality approach [6]. For another example, a task manager, hosted by a smartphone, has been used by young adults with ASD studying at the university [8].

Activity schedules in school context

Recently, activity schedules principles have been explored as underpinnings of the design of assistive technology for ASD children. Specifically, paper-based activity schedules supports are mostly practiced by special education teachers with children with ASD; these supports mostly consist of line drawings or photographs with Velcro© on the back [16]. However, they include limitations for school aides or teachers, such as time to create them and difficulties to record data for tracking student progress [12]. Consequently, activity schedules can be considerably improved when they are based on a multitouch tablet [3, 12]. Hirano et al. developed vSked, an interactive activity scheduling for use in special education classroom [12]. The vSked system was designed to include the benefits of traditional activity schedules (*e.g.,* transitioning between activities, independently engaging in classroom tasks) as well as new functionalities such as dynamic task creation and real-time usage tracking. Cihak et al. supported students with ASD to initiate a general classroom task (*e.g.,* writing, reading or listening), not to follow a sequence of activities [3]. The authors use photos showed to the student, self-modelling task engagement to support the initiation of a classroom task. These photos were inserted into a PowerPoint© presentation on a handheld computer.

Therefore, to the best of our knowledge, there is no study assessing the use of activity schedules to support inclusion of children with ASD in general classrooms. Although their effectiveness has been demonstrated in special education classrooms.

General principles to develop interactive technologies for children with ASD

Prevalently, the research on the design of interactive technologies for children with ASD recommends simplicity, predictability, and clear mappings between actions [11, 13]. Because individuals with ASD tend to process visual information more effectively than auditory information, existing intervention approaches should use visual supports [11, 12, 13]. Since Autism is considered as a spectrum, the severity of the difficulties encountered is extremely variable between children. Assistive technologies must be flexible enough to support each child uniquely, now and as (s)he develops [11]. Distractive stimuli should be avoided. More precisely, they should be mistake-free to reduce frustration (*e.g.,* no error messages, no wrong answers) [13]. These well-known general principles ensure the usefulness and usability of the interactive technologies for children [11, 12, 13]. However, these principles are not enough to ensure that the technology is usable in mainstreamed environments. Indeed, these environments consist of a variety of people, often unaware of the specificities and needs of children with ASD.

Participatory design approach

Participatory design method elicits a great interest in the area of assistive technologies [5] by relying on the active involvement of end-users and the stakeholders to identify needs and constraints. It has been extensively used in the design of technologies for children with ASD [2, 7], notably in the vSked system to identify needs and constraints of special education classrooms [12]. To the best of our knowledge, such approach has not conducted to analyze the needs of students with ASD in the context of their first inclusion in mainstream classrooms. Yet, a participatory approach could allow to identify which activities need support for children with ASD when they are included for the first time in mainstreamed classrooms.

Aim of this paper

We have conducted a participatory design approach to developing an application that provides activity schedules to support children with ASD during their inclusion in mainstreamed classrooms. We have assessed the application's effectiveness with children with ASD at secondary school.

DESIGNING ACTIVITY SCHEDULES

Let us now develop design principles dedicated to making the usage of activity schedules possible in general education classrooms.

3.1 Design Principles

Requirements related to the implicit and explicit rules of general classrooms functioning have been highlighted by the school staff and often in agreement with the litterature. We conducted interviews that resulted in five main principles to be taken into account in the design of our tablet-based activity schedules application.

Activity schedules must promote reading skills

Reading skills is a pervasive need in the school setting. Consequently, supporting this skill in any activity at school fits the school learning objectives. To support this, visual double-coding (*i.e.,* pictorial and textual) has been applied for each step in the sequence of our activity schedules application. Text and visual information are coupled to give children who cannot read the opportunity to associate words to pictures.

Sequences must be short

Classroom instructional flow is critical for some children, especially with ASD. School staff was unanimous on the fact that the intervention had to be as short as possible, to prevent the child from losing track of what is going on in the classroom. Thus, to support inclusion of students with ASD, an activity schedule must be as short as possible (*i.e.,* decomposed into few steps). This principle is consistent with general requirements to create activity schedules [18].

Pictures and sentences must be concrete and idiosyncratic

Each step in the sequence of our activity schedule includes a picture and a sentence. School staff was unanimous on the fact that pictures and sentences must be idiosyncratic (*i.e.,* specific to a person). Furthermore, because of the complexity of multiple concurrent behavioral requirements in an academic setting (*e.g.,* waiting at the door with classmates, waiting for an approval of the teacher, *etc.*), the use of self-modeled pictures, similar to those proposed by Cihak *et al.*. [3], is recommended. For instance, to support a classroom behavior (*e.g.,* to raise hand), students self-modeled pictures should be use (see Figure 1).

Figure 1. Self-modeled pictures of the same action.

Progress status

To help students better manage their time, it is important to give them an indication of their progress in activity schedules. Furthermore, the use of visual timers leads to reducing anxiety - particularly present in mainstreamed classrooms. In doing so, the reduction of maladaptive behaviors may be achieved.

Activity schedules must not use the auditory channel

The intervention inside the classroom must exclude audio materials. First, they would require the use of headphones that would cause a sensory exclusion, precluding the child from participating to the class. Second, headphones would stigmatize the child in front of others students because the use of technology for inclusion must be as unobtrusive as possible.

3.2. Identification of classroom activities

Given these principles, we worked with all stakeholders to list activities of interest in inclusive education classrooms. This step was then followed by a selection of the critical activities that required assistive support.

General listing

We first listed general classroom activities involved in inclusion education with a participatory approach. These activities do not concern academic activities but classroom functioning involving students. Indeed, our technological support is not a pedagogical tool to improve student learning performance, but to guarantee typical classroom functioning. Mainstream teachers, special-education teachers and schools aides have participated to propose general classroom activities to list. For instance, few general classroom activities proposed are : Going into classroom; Answering to classmate; Following explanations or complex directives; Answering questions about a text which comes from it being read *etc.*. A total of 27 general classroom activities have been proposed by these stakeholders.

Priority selection

The second step was to select critical activities in this large selection to not disturb classroom functioning. Indeed, face to critical disruptions, the school staff is frequently forced to suspend the inclusion and to re-place the student with ASD in special education classrooms [10]. Furthermore, to create activity schedules properly, we also selected activities with a clear beginning and end [18]. These critical activities can be respectively regrouped in two general domains: classroom routines and verbal communication (see Table 1).

Classroom Routines	Verbal Communication
Listening and taking notes	Answering the teacher
Going to classroom	Answering a classmate
Leaving the classroom	Talking to teacher
Taking out school supplies	Talking to classmate
Using calendar	

Table 1. The two domains of classroom activities.

3.3. Sequencing

Each activity of the two domains has been decomposed into sequences thanks to methods described in McClannahan and Krantz (1999) [18]. Furthermore, authors related some requirements to follow to create an activity schedule: it must be easy to manipulate, includes at least one social initiation when possible, finishes with reinforcement (*e.g.,* "Finished!") *etc.* [18].

Each classroom activity involves a sequence of steps. We have developed one activity in each domain to show examples. For all verbal communication activities, several choices are possible. For example, in the activity "talking to teacher", 3 choices are proposed: make a comment; ask for an explanation or ask to repeat. These tasks are meant to bring children with ASD to be aware of the goal of their communication. Here is an example of one of them (see Table 2).

Wait at the door with your classmate
Follow them to enter in class
Say hello to your teacher
Find your place
Go to your place
Put your bag down
Remove your coat
Sit down
Finished!

Table 2. Going into the classroom.

APPLICATION DESCRIPTION

Our activity-schedule system runs on a touchscreen tablet. This platform enables rich visual supports and allows the application to be used in any environment. Furthermore, tablets do not carry any stigma as they are increasingly used as portable gaming platforms. Their effectiveness to support intervention has already been demonstrated with children with ASD [6, 12, 13].

Although each student is responsible for her tablet, the school aide can initiate its use. Specifically, she monitors the child and the class flow of activities to determine whether an activity schedule becomes pertinent. When such a situation occurs, she launches the appropriate activity schedule or invites the child to do so thanks to a list of activity schedules is proposed on the top left corner of the screen. Each activity schedule is represented by a text (title) and a little picture (thumbnail). After a while, the school aide only makes sure that the child initiates the use of tablet and the selection of the appropriate activity schedule.

The selection of an activity schedule consists of three stages: (1) the domain of activities, (2) the activity, and (3) the task to be accomplished. These stages are intended to structure the way the child should proceed with the execution of an activity, given that planning (*i.e.,* the activity steps) has been externalized with the tablet. Let us examine in detail each stage. In the first stage, the user chooses between two activity domains: classroom routines and verbal communications (see Figure 2). In the second stage, a list of activities is displayed (top left part of the screen). Notice that in case of verbal communications, these activities are split into two categories: answering and talking. The third stage proposes one of more tasks that address situations within the activity.

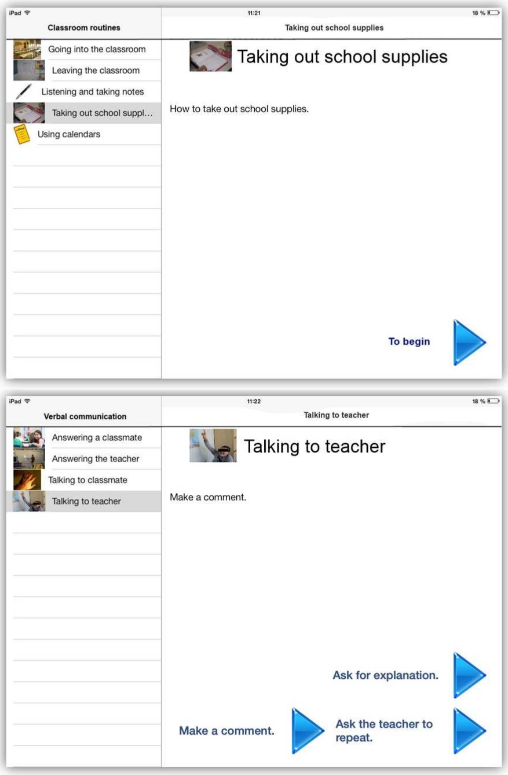

Figure 2. The selection of an activity schedule.

Once the activity schedule is in use by the child, the school aide solely supervises the process. The child is guided through each step of the activity via pictures annotated with instructions. This guiding process is idiosyncratic in that it consists of pictures of the child performing the required steps. An arrow on each side of the screen allows the child to navigate through the steps. Furthermore, a progression bar enables the child to visualize where she is in the activity steps.

EVALUATION

Participants

Our study took place in special education classrooms in secondary schools. A total of 10 students between the ages of 13 and 17 were included in our study. Five of them were children with ASD equipped with *CS+* (five boys), five others were children with ASD non-equipped (four boys and one girl). The two groups were matched by chronological age ($m_{Equipped} = 15.00; SD = 1.22; m_{Non-equipped} = 14.60; SD = 1.14; p > 700$) and intellectual functioning (according to the IQs estimated from abbreviated WISC-IV [9]; $m_{Equipped} = 74.00; SD = 29.83; m_{Non-equipped} = 66.50; SD = 26.72; p > .600$). The group comparisons were tested using a non-parametric test (Mann-Whitney U). Neuropediatricians examined all the children, and the ASD diagnosis was performed according to the criteria of the DSM-IV [1] and with respect to the "Autism Diagnostic Interview-Revised" scale [17]. To assess the severity of social impairment in the school setting, the

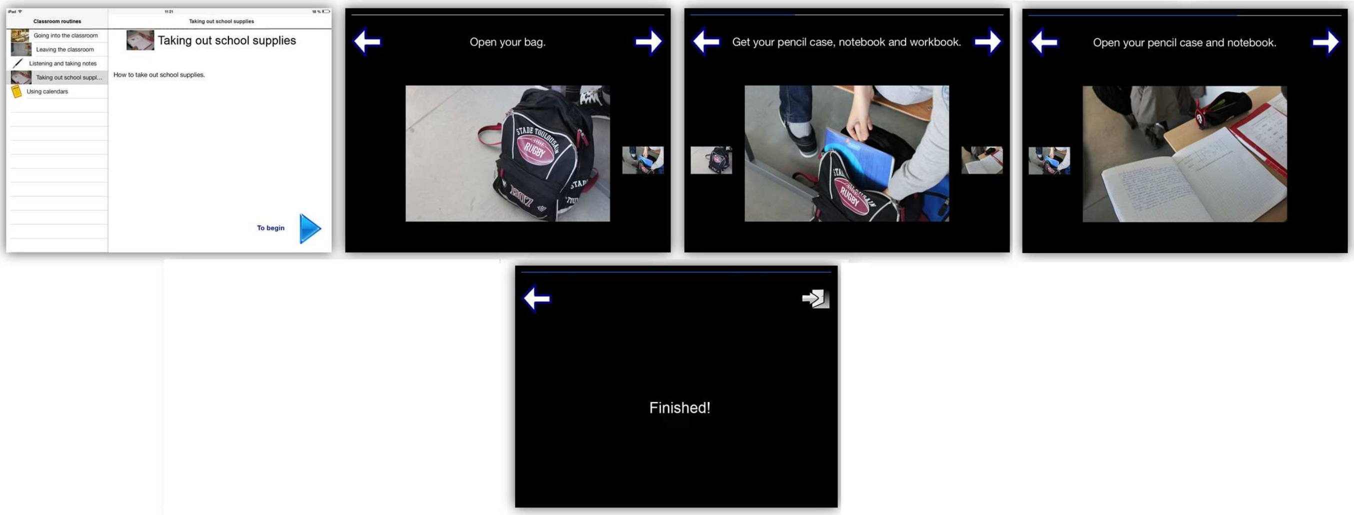

Figure 3. Each steps of the "Taking out school supplies" activity.

teacher of each special education classroom initially completed the French version of the Social Responsiveness Scale (SRS) [?]. Concretely, the SRS provides a quantitative score for social impairment in a natural setting. The two groups of children with ASD had similar school-related social impairment (*i.e.,* $m_{Equipped} = 79.80; SD = 37.42; m_{Non-equipped} = 86.80; SD = 30.51; p > .700$). As recommended by the Helsinki convention, both parental informed consent and children's assent were obtained before participation. Also, the ethics committee of our university approved the experimental protocol, prior to recruiting participants.

Materials and instruments

Besides supporting inclusion of children with ASD in general classrooms, our application collects data regarding its usage (*i.e.,* number of uses in the inclusion class by type of activities). These data are complemented by a behavioral measurement addressing efficacy and usage of *CS+* (see Figure 4).

Classroom Schedule+ efficacy

We have built a specific questionnaire to measure how each task of two activity domains is performed. Each step of each task is assessed by the school aide as follows: the behavior is "unobservable", "not done", "done when requested, with help or badly" or "done autonomously". The scoring is set out as follows: "unobservable" / "not done" are scored 0; "done when requested, with help or badly" is scored 1; "done autonomously" is scored 2. With this, each activity is scored according to its steps. To analyse results, we first put scores of activities into a percentage format as follows: if each step of the activity is scored 2, the percentage of this activity is 100. In this case, the child is able to realize the activity autonomously. Second, we average percentages of activities related to a given domain, a percentage on classroom routines and verbal communication, for each child.

Classroom Schedule+ usage

This part of assessment included school aide observations about the *CS+* usage by each child and log data extracted from our application.

- Autonomous usage: at the end of each month of intervention, the school aide was asked to indicate whether the child used the application in full autonomy and in an adequate manner (scored 1) or whether (s)he had needed help to use it (scored 0).

- Number of routines activated: from the log data, the number of routines activated during the classroom inclusion period is collected (*i.e.,* for each classroom inclusion during one month period).

Procedure

Prior to our intervention, we held a meeting with the inclusion teachers, the special education teacher, the school aides, the parents, and the children. The goal was to give them an overview of our procedure (see Figure 4), to explain the importance of using our application on a regular basis, and to answer all their questions. We also gave a demonstration of our tool, explaining its functioning. At the baseline assessment session, the special education teacher of the children with ASD completed a demographic information form and the SRS scale. The children completed the abbreviated WISC-IV. The participants were then observed during their inclusion in the classroom (French, mathematics, history, geography, or biology) for two weeks. In the context of our intervention, each participant attended a new class where new situations could occur. It was a one-hour class that occurred once a week during a period of three months. A school aide accompanied each child during inclusion. Each school aide was trained to support students with ASD. In addition, they were told how to use *CS+* to play the role of social support during inclusion. During each class in inclusion, the school aide completed a specific questionnaire to collect the activity observations for each child (that are equipped). All post-intervention measures were completed within two weeks after the end of the three-month intervention. All interviews were conducted at school or at home.

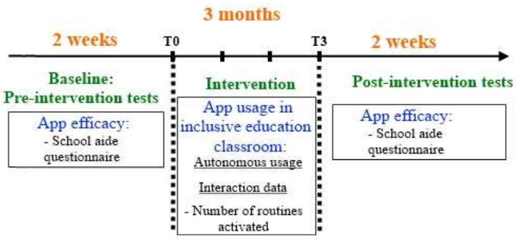

Figure 4. An overview of our procedures

Design and statistical treatments

For efficacy measure, a mixed factorial design is implemented with two within factors and one between factor. The within factors were activity domain, which had two levels (Classroom vs. Communication) and Time, which had two levels (pre- and post-intervention). The between factor was Group, and it had two levels (Equipped and Non-equipped). For the autonomous use measure, the Friedman test is used with the Time factor (after one month, two months, and after three months of intervention) as the independent variable. For the log data from *CS+*, the factorial design included only within factors with: activity domain, which had two levels (Classroom vs. Verbal communication) and Time, which had two levels (after one month and after three months of intervention). All the dependent measures were numeric. All the pairwise comparisons were carried out with non-parametric procedures as recommended for small-size samples with non-normal distributions, notably the Mann-Whitney U (between-factor) or the Wilcoxon (within-factor) test. We used SPSS 19.

Results

Overall, the results support the efficacy of *CS+* in showing that both classroom and verbal communication routines performed in general education classrooms were significantly more enhanced for the ASD children equipped compared to those not equipped. Note that the pre-post progress were higher in classroom routine domain than in the verbal communication domain for all the children. In addition, the observation from the school aide indicated that the children reached a autonomous *CS+* usage from the second month of use. Finally, log data indicated that the use of *CS+* was high and unchanged across time for activity schedules within the verbal communication domain. By contrast, within classroom routines domain, the use of *CS+* was high only during the first month of classroom inclusion and was considerably decreased in the third month of use.

Classroom Schedule+ Efficacy (see Figure 5). The ANOVA revealed significant effects for Activity domain $[F(1,8) = 62.74; p < .0001]$ and Time factor $[F(1,16) = 32.50; p < .001]$ on the routines correctly performed in classroom. The interaction effect including Time and Activity domains was also significant $[F(1,8) = 14.47; p < .01]$ and showed that the performance increase with time was higher on verbal communication than on the classroom routine domain for both conditions of ASD children. Importantly, the interaction between Group and Time factors stated that the performance increase with time was significant for children with *CS+* $(z = -2.80; p < .01)$ whereas this is not obtained for children not equipped $(z = -1.35; p > .100)$.

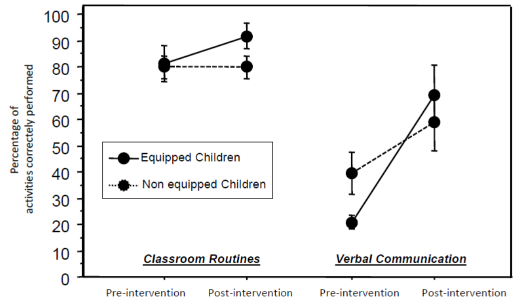

Figure 5. Percentage of activities correctly performed on classroom according to activity domain and group condition.

Classroom Schedule+ usage in inclusive education classroom

- Autonomous usage measure: the time factor effect was significant $[\chi^2 = 6.50; p < 04]$: a mostly autonomous usage of our application reached by the children after two months $(M_{after\ one\ month} = 0.20; SD = 0.44; M_{after\ two\ months} = 0.80; SD = 0.44; M_{after\ three\ months} = 1.00; SD = 0.00)$.
- For the number of routines activated: the ANOVA revealed a main effect of time factor $[F(1,4) = 12,24; p < .04]$ indicating that the number of activated routines decrease with time. Also, although the interaction effect (Time * Activity domain) did not reach the significance $(p > .05)$, the post-hoc comparisons indicated that the use of *CS+* did not differ for classroom routines and verbal communication condition during the first month $(z = -0.36; p > .700)$, while its use for classroom routine domain was lower than for verbal communication domain during the third month period $(z = -2.02; p < .04)$ (see Figure 6).

DISCUSSION

To the best of our knowledge, there is no study assessing a technological device for activity schedules to support children with ASD in mainstreamed school environments. Additionally, we found no study addressing the activity schedules with idiosyncratic contents to provide assistive support for first-time inclusion of ASD children in general education classroom. The results presented here provide insights on these issues.

Efficient and autonomous use in mainstreamed environments

Our empirical results demonstrate that *CS+* provides children with ASD with a relevant task-management

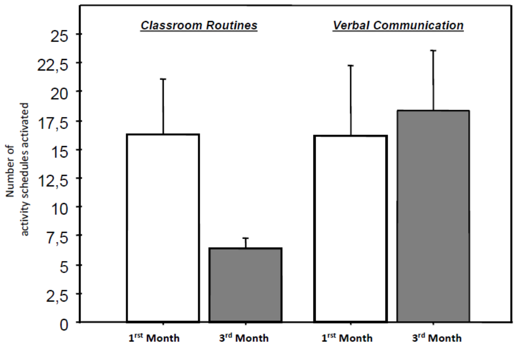

Figure 6. Number of routines activated as a function of activity domains and intervention duration

support in mainstreamed environments, such as a classroom. Importantly, the socio-adaptive routines in class were greatly enhanced for equipped children with ASD, despite the short intervention time (*i.e.,* only three months). We also observe high usability of our application (*i.e.,* independent use after the 2nd month). The limited-steps interaction within one activity schedule and only two user-pointing inputs (forward and backward arrows) allow children to quickly and easily follow the critical steps of each routine for a short time. As a result, interface organization, interaction duration as well as idiosyncratic contents probably maximize the device's adoption while ensuring a child's effective presence in the classroom.

Relevance of flexible visual supports for activity schedules in school settings

Interestingly, for all the children (equipped or not), the pre-post progress was higher in the classroom routine domain (with nearly perfect execution) than in the verbal communication domain (≈ 70% correctly performed). A related result comes from the log data. Indeed, we reported a decreased use of *CS+* in time for classroom routines contrasting with a high and constant use of *CS+* for verbal communication domain. This usage discrepancy is probably due to differences in socio-cognitive demands of to-be-performed tasks into the two domains. So, the more a child becomes proficient in an activity domain, the more (s)he performs the domain-related tasks autonomously, and the less (s)he uses the corresponding contents of *CS+*. This means that the child is able to select the contents of *CS+* appropriately with respect to her own progress and needs: probably, classroom routines meet a child's needs related to the start of classroom inclusion, while verbal communication routines are persistent needs for classroom life of children with ASD. Note that *CS+* is built as a learning and assistive device with flexible contents, so when a routine is acquired by child, stakeholders can create new adapted ones. This is possible thanks to the independent management of interface and contents in *CS+*. Indeed, routines (texts, pictures and step numbers) can be changed while the interface skin remains the same, which is desirable for children with ASD [11, 13].

Relevance of idiosyncratic and concrete contents for activity schedule in school settings

Both efficacy and quick autonomous usage of *CS+* suggests the superiority of idiosyncratic visual supports over general-purpose ones [20]. In light of the diversity and complexity of tasks having to be resolved in a school setting (*e.g.,* waiting at the door with classmates, waiting for an approval of the teacher, *etc.*), the use of self-modeled pictures provides illustrations of the particular child in context. This is in favor of imitative behaviors [3]. In this experiment, we included children with IQs around 70, thus, such idiosyncratic visual supports probably meet their concrete reasoning abilities well.

Collaborative design induces technology acceptance

The collaborative nature of our intervention allowed our tool to be pervasively accepted by all stakeholders of the child's mainstreamed environment. Teachers, especially, played a major role in facilitating the application usage inside their classroom. For instance, they encouraged children to use our application with sentences like "you should have a look at your tablet".

Limitations and Future Work

Regarding the participating children, their number did not reach a sufficient sample size for statistically conclusive results, even though the use of non-parametric statistical tests has been respected. Also, the participating children did not cover the spectrum of intellectual functioning. Consequently, it remains to be shown that our results carry over to children with ASD that are on the higher end of the spectrum of intellectual functioning. To further explore our research avenue, an interesting direction would be to add a set of routines that covers all the aspects of task-management for supporting the participation of children with ASD in mainstreamed school settings. For instance, applications designed to manage tasks may be helpful for self-initiating adaptive behaviors in other school settings (such as canteen, schoolyard, school bus, *etc.*).

CONCLUSION

This paper presents a tablet application (*Classroom Schedule+*) supporting task-management skills of children with ASD in mainstreamed environments. This application has been used by five children with ASD during their inclusion in secondary schools. All children successfully adopted our application and have exhibited increased socio-adaptive behaviors in classroom. With a participatory design approach, we identified critical activities for ASD children and design principles that allowed *Classroom Schedule+* to be infused in a mainstreamed environment: the general education classroom. With a similar approach, other applications could be implemented to offer more adaptability to closely match the needs of children with ASD for school and other mainstreamed settings.

REFERENCES

1. Association, A. P. *Diagnostic and statistical manual of mental disorders: DSM-IV-TR®*. American Psychiatric Pub, 2000.

2. Benton, L., Johnson, H., Ashwin, E., Brosnan, M., and Grawemeyer, B. Developing ideas: Supporting children with autism within a participatory design team. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM (2012), 2599–2608.

3. Cihak, D. F., Wright, R., and Ayres, K. M. Use of self-modeling static-picture prompts via a handheld computer to facilitate self-monitoring in the general education classroom. *Education and Training in Developmental Disabilities 45*, 1 (2010), 136.

4. Cramer, M., Hirano, S. H., Tentori, M., Yeganyan, M. T., and Hayes, G. R. Classroom-based assistive technology: collective use of interactive visual schedules by students with autism. In *CHI* (2011), 1–10.

5. Druin, A. The role of children in the design of new technology. *Behaviour and information technology 21*, 1 (2002), 1–25.

6. Escobedo, L., Nguyen, D. H., Boyd, L., Hirano, S., Rangel, A., Garcia-Rosas, D., Tentori, M., and Hayes, G. Mosoco: a mobile assistive tool to support children with autism practicing social skills in real-life situations. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems*, ACM (2012), 2589–2598.

7. Frauenberger, C., Good, J., and Keay-Bright, W. Designing technology for children with special needs: bridging perspectives through participatory design. *CoDesign 7*, 1 (2011), 1–28.

8. Gentry, T., Wallace, J., Kvarfordt, C., and Lynch, K. B. Personal digital assistants as cognitive aids for high school students with autism: results of a community-based trial. *Journal of Vocational Rehabilitation 32*, 2 (2010), 101–107.

9. Grégoire, J. *L'évaluation clinique de l'intelligence de l'enfant: Théorie et pratique du WISC-III*, vol. 229. Editions Mardaga, 2000.

10. Harrower, J. K., and Dunlap, G. Including children with autism in general education classrooms a review of effective strategies. *Behavior Modification 25*, 5 (2001), 762–784.

11. Hayes, G. R., Hirano, S., Marcu, G., Monibi, M., Nguyen, D. H., and Yeganyan, M. Interactive visual supports for children with autism. *Personal and ubiquitous computing 14*, 7 (2010), 663–680.

12. Hirano, S. H., Yeganyan, M. T., Marcu, G., Nguyen, D. H., Boyd, L. A., and Hayes, G. R. 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 (2010), 1633–1642.

13. Hourcade, J. P., Williams, S. R., Miller, E. A., Huebner, K. E., and Liang, L. J. Evaluation of tablet apps to encourage social interaction in children with autism spectrum disorders. In *Proceedings of the 2013 ACM annual conference on Human factors in computing systems*, ACM (2013), 3197–3206.

14. Hunt, P., and McDonnell, J. Inclusive education. *Handbook on developmental disabilities* (2007), 269–291.

15. Koyama, T., and Wang, H.-T. Use of activity schedule to promote independent performance of individuals with autism and other intellectual disabilities: A review. *Research in developmental disabilities 32*, 6 (2011), 2235–2242.

16. Lequia, J., Machalicek, W., and Rispoli, M. J. Effects of activity schedules on challenging behavior exhibited in children with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders 6*, 1 (2012), 480–492.

17. Lord, C., Rutter, M., and Le Couteur, A. Autism diagnostic interview-revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of autism and developmental disorders 24*, 5 (1994), 659–685.

18. McClannahan, L., and Krantz, P. Activity schedules for children with autism: Teaching independent behavior. *Woodbine House* (1999).

19. McCurdy, E. E., and Cole, C. L. Use of a peer support intervention for promoting academic engagement of students with autism in general education settings. *Journal of autism and developmental disorders* (2013), 1–11.

20. Park, J. H., Abirached, B., and Zhang, Y. A framework for designing assistive technologies for teaching children with asds emotions. In *CHI'12 Extended Abstracts on Human Factors in Computing Systems*, ACM (2012), 2423–2428.

21. Sampath, H., Indurkhya, B., and Sivaswamy, J. A communication system on smart phones and tablets for non-verbal children with autism. In *Computers Helping People with Special Needs*. Springer, 2012, 323–330.

22. Tentori, M., and Hayes, G. R. Designing for interaction immediacy to enhance social skills of children with autism. In *Proceedings of the 12th ACM international conference on Ubiquitous computing*, ACM (2010), 51–60.