# Chapter 4
# Supporting the Strengths and Activity of Children with Autism Spectrum Disorders in a Technology-Enhanced Learning Environment

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## 4.1 Introduction

The contents of this paper reflect a research project that investigated the actions of children with ASD in a strength-based technology-enhanced learning environment (Vellonen et al. 2013; Voutilainen et al. 2011). The structure of the paper is twofold. First, the paper will introduce four principles for the establishment of a strength-based technology-enhanced learning environment, and second, it will present and discuss the findings of how such a learning environment worked for children with ASD. The term ASD refers to abnormalities in the areas of social interaction, communication and repetitive behaviors (American Psychiatric Association 2000; World Health Organization 1992). In addition, speech is typically delayed and some children are nonverbal or have sparse, limited speech (Rapin and Tuchman 2008). Children participating in this project had various autistic features and limited verbal communication.

Learning environment is a term used both in connection with a range of specific areas of education and to convey broad ideas about learning. The project rests on Barry Frazer's (1998) broad definition of a learning environment. According to Frazer (1998), learning environment refers to the social, psychological and pedagogical contexts in which learning occurs and which affect student achievement and attitudes. In addition, information technology (IT) learning environments are included explicitly (Frazer 1998). However, this paper focuses on the pedagogical and technical aspects of the learning environment.

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A crucial component of a good learning environment is assessment as systematic preparation for effective intervention. Assessment, planning, and facilitation need to focus on helping children on the autism spectrum develop the understanding and skills that will enable them to access the curriculum, engage in learning, and experience true inclusion. While a diagnosis might give a signpost to the needs of a child or young person on the autism spectrum, identification of those needs can only arise from an understanding of how the condition affects the individual at a particular time and in a particular learning environment (Parsons et al. 2009, 2011).

A learning environment's characteristics, for example, class arrangements, computers, laboratory experiment kits, teaching methods, learning styles, and assessment methods, influence learners' academic achievements, and other learning outcomes in cognitive and affective domains (Doppelt 2006, 2004; Doppelt and Schunn 2008). The impact is even more remarkable when learners have special needs such as autism (Sze 2009; Verdonschot et al. 2009; Williams 2008; Williams et al. 2006). A growing number of studies suggest that interactive causal multisensory environments are stimulating for people with disabilities (Williams 2008; Williams et al. 2006). In addition, recent research indicates that children with ASD, for example, benefit from environments that provide structure while allowing them to express their personalities in the learning choices they make (Sze 2009).

There is evidence that an "autism friendly" environment needs to be based on individual assessment and focus on social understanding and communication, be developmental and structured, and use visual supports (Guldberg 2010; Parsons et al. 2011, 2009). Potential sensory processing difficulties must be taken into account and environments adapted accordingly (Bogdashina 2003; Frith 2003). It is also important to consider a number of other dimensions, including teaching practices, learning contexts, and child characteristics, when building a supportive and activating learning environment for children with ASD.

The technology-enhanced learning environment of the project introduced in this paper included four technology solutions for children's learning. The versatility of the technology solutions meant possibilities to foster children's creativity and potential skills which a single technology solution might not have been able to emerge. With respect to its strength-based learning environment focus, this paper stresses the importance of establishing and developing a learning environment based on the strengths (e.g., special skills, interests) and creativity of children with ASD rather than on the problems and deficits associated with autism. This emphasis on strengths and creativity is important as these aspects have been less researched and understood than other features of autism (Happé and Frith 2009).

## 4.2 Strength-Based Technology-Enhanced Learning Environment

There were four main principles that established the learning environment in this research project: (1) Children's creativity and active roles; (2) Children's strengths; (3) Modifiability of technologies; and (4) Transformability of technological solutions to everyday life contexts. The findings of previous studies (e.g., Jormanainen et al. 2007; Kärnä-Lin et al. 2007) provided the criteria for the selection of these four principles. Previous research further suggests that flexible, choice-based, and tangible technologies in cooperation with appropriate and inspiring pedagogical content can compensate for learning challenges, and change the child's role from technology user to active participant and creator in a technology-enhanced learning environment (Robins et al. 2005).

1. *Children's creativity and active roles as participants and developers in a technology-enhanced learning environment*. This first principle investigated the diversity and creativity in children's behavior—aspects that have been less researched compared to the more typical features of ASD (e.g., repetitive and invariant behavior) (Napolitano et al. 2010). The learning environment enabled the children's active role by letting the children interact with many kinds of technologies. The technologies were selected to be diverse so that the children could use them in various ways through different kinds of interfaces (e.g., touchscreen, mouse, physical tiles, and motion-based interface). The various and changing pedagogical contents of technology applications (e.g., funny games, number and picture tasks, creating stories, building models) were to tempt the children's engagement and creativity.
2. *Comprehensive support of the emergence of children's strengths*. The majority of research on children with autism and technology attempts to find solutions to problems connected to ASD (e.g., Austin et al. 2008; Bernard-Opitz et al. 2001; Powers 2006). This learning environment, however, focused on children's strengths during activities in the environment, and there were several ways to support the emergence of children's strengths. The use of multimodal interaction, the utilization of different senses (visual, auditory, tactile, and kinesthetic), and the individual modifiability of technical solutions could help determine the children's individual strengths. In addition, a roomy space with minimal external stimuli was provided to support children's concentration on activities at workstations and give them a chance to monitor or to interact with other children while working in the environment. Also, action group session routines (e.g., joint beginning of the session) were to enhance the clarity of the learning environment. However, as the environment was meant to be as natural as possible, changes in routines and the organization of the environment were possible when needed.

   Another important means of supporting the emergence of children's strengths was the use of augmentative and alternative communication (AAC) methods in the learning environment. First, AAC methods (especially pictures and signs) were used adaptably in instructing the children according to the children's teachers' and school assistants' evaluations. Second, the children had a picture of the action group in their weekly timetables so they knew the date and time of the session in advance. Third, the applications used a variety of pictures (e.g., hand-drawn pictures, photos) so that the children became familiar with different kinds of visual symbols and representations. Fourth, pictures were used to clarify the structure of the sessions; for example, each child used a pictured map that presented the order of the workstations as a guide to move from one station to another. Fifth, the children provided workstation feedback by way of picture symbols.

3. *Modifiability of technologies*. This principle emphasized the children's active role and creative actions in the learning environment. Pedagogical content and technological implementation of applications are often predefined before use in learning environments because they are often designed for specific purposes and certain learning objectives; therefore, children and teachers rarely have opportunities to modify physical technology devices or content. Technology solutions with specific purposes for children with ASD are, for example, mobile devices to improve communication skills (see De Leo and Leroy 2008) and scheduling (see Hayes et al. 2008), virtual learning environments and computer games for developing social skills (see Battocchi et al. 2009; Cheng et al. 2010) and games for exercising (see Finkelstein et al. 2010), and robotics for improving social skills (see Fujimoto et al. 2010). These technology solutions have indicated advantage for children with ASD within the specific purpose, but by enabling the modification of the pedagogical content, the solutions might be applicable to other educational domains.

   The learning environment established in this research project realized the modifiability of technologies by enabling modification of physical elements (e.g., physical tiles) and pedagogical content (e.g., tasks and visual content) to applications by both children and adults. Choices for modification were based on the children's interests and iterative feedback after participation at the workstations and observations of the children's actions at the workstations. Thus, the participating children had an untraditional and unique role in the study since they operated as innovative and active research partners (Druin 2002; Marti and Bannon 2009; Olkin 2004) rather than just as objects of inquiry. The teachers' and school assistants' roles were also important in the development of the technologies since they knew the children's individual pedagogical goals in school.
4. *Transformability of technology solutions to everyday life contexts*. Commercially available technologies (e.g., robotics) are often too expensive to use in education (Bryant et al. 2010). Another obstacle to applying and transforming technology solutions to everyday life contexts is how time-consuming technologies are for teachers to learn and how difficult they are to use (Copley and Ziviani 2004). Research on advanced technologies confirms children with ASD benefit from various technologies (Finkelstein et al. 2010; Williams et al. 2006; Williams et al. 2002) and thus, supports applying technologies in education for them. It is therefore important that applications are easy to use and modify without technical expertise or external support to fit children's needs and wishes in everyday life contexts, like school.

## 4.3 Method

The research participants included two groups ($N=8$) in one comprehensive school for children with special needs. Group A participated in the research from the beginning of the project, February 2011. This group included four children with autistic features and limited verbal communication. Two were boys (ages 8 and 10 years at the beginning of the project) and two were girls (ages 7 and 12 years at the beginning of the project). Group B was included in September of 2013 to evaluate the development of the learning environment thus far with novel participants. Group B included four boys with autism (ages 8, 10, 11 and 11 years at the beginning of their participation).

The children faced many challenges in their actions and learning, yet had multiple strengths, such as good visual senses, and a variety of skills in information and communication technologies (ICT). Each child had various ways of communicating despite limitations in verbal language skills. All of the children used augmentative and alternative communication methods, especially picture symbols, in various situations.

The children's teachers and school assistants participated in the research project by providing valuable information about the children's interests and needs, and knowledge about their actions in their respective classrooms. They knew the children better than the project researchers did and were, therefore, ready to support the children when needed. In addition, the teachers and school assistants provided feedback about the learning environment during the study and were involved in the technology development process. By participating in the project with the children, the teachers and school assistants received firsthand knowledge about the children's actions in the technology-enhanced learning environment.

The study was conducted following generally accepted ethical principles for scientific research. Participation in the study was voluntary, and written informed consent was obtained from the children's legal guardians. Additionally, the teachers and school assistants were asked for written informed consent. Respecting the rights of the participants was given the first priority in the study.

### *4.3.1 Settings*

The research project ran one-hour group sessions, called action groups, weekly, nine times each semester. At the beginning of each session, there was a short warm-up with greetings and the researchers gave the children a pictured map of the workstations. Though the order of the workstations was predetermined, the children could choose a variety of tasks or games to work with at each workstation. The children worked individually at each station for 10–15 min, and the adults were advised to help if needed (e.g., setting the difficulty level of the task). The order of the workstations varied for each child every session. After group B joined the study, the children were divided in two groups according to their school schedule and thus, the project ran two one-hour group sessions in a row.

A technology-enhanced learning environment was set up in a spacious room in the school building (Fig. 4.1). There were four technology workstations in the learning environment: symbol matching, LEGO® building, storytelling, and Kinect playing (Figs. 4.1 and 4.2).

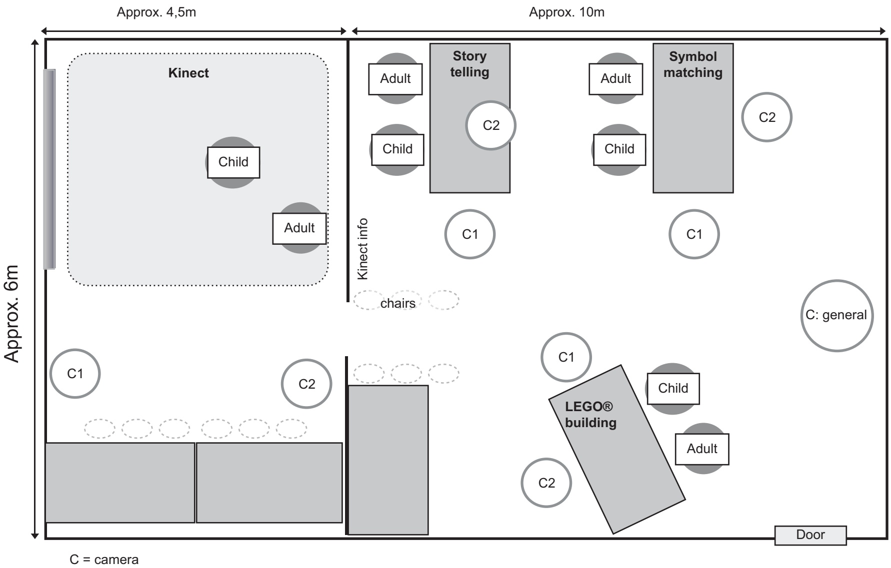


**Fig. 4.1** Ground plan of the technology-enhanced learning environment


**Fig. 4.2** Symbol matching, LEGO® building, storytelling, and Kinect playing

At the symbol matching workstation, the children had tasks of matching a symbol from the computer application to the corresponding symbol or a theme by pressing one of six tiles. The children chose the topic for the tasks and changed the symbol cards on the tiles according to their selection by themselves. The tasks included, for instance, recognizing hiding creatures, categorizing according to hypernyms (e.g., space, animals, musical instruments), recognizing initial letters of words, and matching a certain amount of objects to corresponding numbers.

At the LEGO® building workstation, the children built a LEGO® Duplo or basic LEGO® construction from the model on the computer application. The children chose a task from three alternatives: (1) building from the picture of the whole model; (2) step-by-step building of the model; or (3) a memory game that hid the model during the child's construction. In addition, the children chose between building a model according to a certain character (e.g., various animals) or a random model. The children adjusted the difficulty level by changing the number of the bricks in the application. During the project, new character models were included.

At the storytelling workstation, the children created stories by using a picture-based computer application and a touchscreen. The pictures were categorized, and the children created stories by dragging and dropping the hand-drawn pictures into the story's timeline, as well as by drawing pictures of their own. During the project, the application was modified and, in fall 2012, the children could also write the name of the story above the storyline, write text under the pictures and record the story to be listened to later. The stories were saved to the story library where the children could review and continue their own stories, and review the stories created by other children. The children could print out their stories and put together their own story books.

At the Kinect playing workstation, the children played games that used Microsoft's Kinect sensor. During 2011 and 2012, the children played short Kinect Adventures! games by Microsoft Game Studios. During 2012, a new catching game was developed in the project and, in fall 2012, it replaced the previously used commercial games. The children played the catching game by picking moving objects (e.g., fishes, birds, letters). In the new game, the background and objects were modifiable based on the children's individual skills and interests. The children played both the previously used commercial games as well as the project's catching game by using their whole bodies to control the game, for instance, jumping, dodging, and using their hands. In addition, all games allowed using a variety of movements as long as the player stayed within the play area.

The pedagogical aspects were carefully considered in developing the technology-based workstations. These aspects included, for example, supporting children's communication and using visual supports (e.g., Guldberg 2010; Parsons et al. 2011, 2009), supporting the children to use various senses (e.g., Bogdashina 2003; Frith 2003), providing structure but also allowing the children to make choices (e.g., Sze 2009), and emphasizing the children's strengths and creativity instead of difficulties (e.g., Happé and Frith 2009). There are examples of the advantages of the workstations with regard to supporting the children's strengths and activities, and in applying the workstations in a school context in Table 4.1.

**Table 4.1** Examples of the pedagogical possibilities in applying the workstations in a school context

| Workstation | Examples of the advantages of the workstation considering a school context |
|---|---|
| Symbol matching | Various visual symbols in the tasks (e.g., photographs, a variety of drawn pictures) to attract attention and to get familiar with working with different kinds of visual symbols.<br>Working with visual or auditory instructions allows using individual strengths.<br>Written words or instructions in the tasks support developing reading skills.<br>Interaction and communication supported by means of doing the tasks with another person.<br>Using creativity by reconstructing the tiles (see Korhonen et al. 2010).<br>By modifying the contents of the application, the workstation could be integrated into almost any school subject |
| LEGO® building | Working with smaller LEGO® basic bricks or bigger LEGO® Duplo bricks according to skills and preferences allows using individual strengths.<br>Selecting models according to individual strengths and interests.<br>Building with bricks practices working with colors, sizes, numbers, and spatial directions.<br>Visual instructions of the models (e.g., stable or rotating model, direction of the model) could be adjusted by the builders themselves according to their interests and needs.<br>Interaction and communication supported by means of constructing LEGO® models with another person.<br>School subjects like mathematics could utilize this kind of workstation |
| Storytelling | Expressing oneself by creating stories with different kinds of pictures (e.g., drawn pictures, photographs) and one's own drawings.<br>Recording sounds, words and phrases in relation to pictorial stories to encourage verbal expression and creativity.<br>By creating stories, practicing categorizing, conceptualizing, and naming.<br>By naming the stories, practicing writing.<br>Choices and actions in a free or more structured way according to individual strengths and interests.<br>Interaction and communication supported by means of making stories together and sharing stories.<br>Visually supported social stories to different kinds of everyday life situations.<br>This kind of workstation could be applied especially in the mother tongue but, by modifying the contents, could be integrated into almost any subject |

**Table 4.1** (continued)

| Workstation | Examples of the advantages of the workstation considering a school context |
|---|---|
| Kinect playing | By playing amusing games, attracting attention, exercising and practicing perceiving and targeting motions.<br>Interaction and communication supported by means of playing with another person.<br>Using creativity by modifying the games, for instance, by drawing the background of the game.<br>The workstation could be applied especially in physical education (various movements while playing), studying languages (e.g., collecting letters for a word) and mathematics (e.g., amounts and numbers). By modifying the content, it could be applied to almost any school subject |

The children gave immediate feedback about the workstations after interacting with the technologies. The feedback system consisted of a black piece of cardboard with three picture-word feedback cards and a photo of the workstation. The feedback cards had drawn pictures of facial expressions (linked with matching words): very happy face (I liked it a lot), neutral face (I liked it a little), and sad face (I didn't like it). In this respect, the feedback scale was similar to one used with children in technology development projects using a participatory design model (see Nissinen et al. 2012; Read and MacFarlane 2006; Read et al. 2002).

### *4.3.2 Data Collection and Analysis*

The project conducted qualitative action research (Heron and Reason 2001; Ladkin 2004). The main research data were collected by videotaping each child's actions using two video cameras per workstation: one facing the child in front of him/her, and the other facing the child with the screen sideways. The purpose of this was to be able to analyze the child's actions while seeing what was happening on the screen at the same time. The additional data were collected by observing the children during the action group sessions, and by interviewing teachers and school assistants.

This paper's findings are based on the data collected in the action group sessions between February, 2011, and December, 2013. The researchers analyzed the data via content analysis (e.g., Bauer 2000) by organizing and reviewing the data according to the four principles that guided the establishment of the learning environment. Thus, the categories of organizing and reviewing the data were the following: the emergence of the children's creativity and activity, the emergence of the children's strengths, the modifiability of the technologies, and the transformability of technological solutions to an everyday life context. A few short examples of the transcriptions of the video data clips and observation notes have been included in the following results section. The examples have been transcribed into English and the children's names changed to pseudonyms to protect their identities.

## 4.4 Results

According to results, the project's strength-based technology-enhanced learning environment facilitated the emergence of the children's activity and creativity; the first principle of the establishment of the learning environment. For instance, the children immediately started using the applications or choosing equipment linked to the workstations (e.g., cards for the tiles) upon arriving at the stations, and quickly learned compensatory ways to proceed if there were problems with the technologies (e.g., using buttons on the keyboard instead of out-of-order tiles) or the equipment (e.g., using red bricks instead of missing orange bricks). Similar to many previous studies (e.g., Finkelstein et al. 2010; Williams et al. 2006; Williams et al. 2002), the technology itself was motivating for all children participating in the project. According to the findings, the versatility of the workstations in the environment and the possibility of making choices at each workstation seemed to support the active role of the children.

All of the participating children showed interest in the new application features and new tasks or games in the environment. The participating children's interest in novelty was remarkable considering many researchers report that children with ASD have restricted interests (see Ala'i-Rosales and Zeug 2008; Baron-Cohen and Wheelwright 1999; Folstein and Rosen-Sheidley 2001). While the researchers executed changes in the learning environment based on routines familiar to the children, the children's interest in change emerged from the beginning of the project, even when the workstations and procedures were novel to them. The children usually explored the new application features or tasks introduced to them and, if they found them appealing, chose them again. Below is an example of group A's actions regarding a new task.

> At the beginning of the session, we presented a new task for the symbol matching workstation called "Hypernyms task." Iris, Ian, and Olivia chose the new task as the first task at the workstation. Eric scanned the new cards during his turn. The school assistant asked if he wanted to take on the new task. Eric immediately started to place the new cards into the tiles. (Observation notes, March, 2012)

The role of the teacher or school assistant working with the child in the technology-enhanced learning environment was also significant in many respects. The teachers' and assistants' contributions were important in helping the children overcome possible problems in an application's functionality or a task's difficulty. In addition, the school assistant's positive tutoring and feedback were relevant in helping the given child grasp a new task and learn to do the task by him/herself, as the next example illustrates.

> The school assistant takes Ian's finger and points with it on the screen and they count together: "one, two, three, four, five, six." The assistant asks Ian, "Where is six?" Ian presses the tile number 6 and the assistant whispers, "Good."
> When the next photo appears, the assistant whispers, "Let's count," and points at the screen from farther away. Ian counts the number of the objects on the screen by pointing at the objects himself and says, "one, two, three, four, five." Ian presses the tile numbered 5.

> The assistant whispers, "Good," and shows her thumb up. Ian smiles. (Transcription of a video data clip, November, 2011)

It was also important that the adults provided room for the children's actions to support their activity and creativity. As a consequence, over time the need for tutoring decreased and the children were able to work at the stations more independently even though there were individual differences in the amount of time and the nature of the activities during which each child could work more independently. For example, during the data collection period of this study, two of the children from group A occasionally worked totally independently in the environment, as long as there were no problems with the technologies. The children in both groups also discovered novel features of the tasks. Once the content of the task was interesting, or if the task started to become familiar, some of the children initiated variation and multiple means to complete the tasks, for instance, by verbally describing pictures on the screen in various ways. In addition, the children found varied ways to use the technologies by themselves, for example, pressing the tiles or controlling the touchscreen with either of the hands, by the tips of different fingers, or by using the side of the hand. Thus, the children showed creativity in their actions.

Considering the results, the technology-enhanced learning environment also brought out the children's potentials and strengths; the second principle in the establishment of the learning environment. As knowledge of the children's strengths, and often of the children's interests, was iteratively executed, both in the content of the tasks (e.g., appealing themes) and games (e.g., modifiable objects and background), and in the workstations' technical aspects (e.g., sensitive touchscreen for drawing, microphone for recording expressions by voice), the environment kept changing and thus continuously fostered emergence of the children's strengths. Their strengths varied from good visual perception to creating detailed drawings to athletic skills. Below is an example of one child's (group A) skills in making choices independently and moving fluently; skills which emerged especially in this environment since his actions were not very self-directed in the classroom setting.

> Ian trots to the play area at the Kinect playing workstation, chooses the first game, and plays it independently. Ian moves fluently and quickly in different directions during the game (stepping left and right, hands up, hands down, hands diagonally, stepping forward and backward, jumping) and collects lots of points. When he finishes the game, the school assistant says, "Really well, Ian, great," and claps her hands. (Transcription of a video data clip, November, 2011)

According to the results, the versatility of the environment quickly brought out strengths and potential regarding the children in the new group (B) as well. For instance, one of them turned out to be very skilled in drawing and telling stories. He also acted very fluently with the technologies, as the next example of the storytelling workstation illustrates.

> Aron picked up several pictures of the folder containing his own drawings to the storyline and pressed the symbol indicating that the story was ready. He took the microphone and started recording verbal expressions, some of them indicating conversation (question and answers), and also sounds. During recording, he moved the pictures of the story forward on the touchscreen. At the end of the storyline he had a picture in which he had written "the

> end", and he said it aloud. He recorded for 1 min 25 s. He then listened to his own story and moved the storyline on the screen accordingly. (Transcription of a video data clip, December, 2013)

The project iteratively realized and fulfilled the modifiability of technologies; the third principle of the establishment of the learning environment. The children's iterative feedback was utilized in the modification process; however, the challenge at the beginning of the project was to get feedback from the children. Because the children were inexperienced in giving feedback, the researchers needed to carefully consider how to ask them for feedback. The feedback system described above seemed to work, as the next example shows.

> After acting at the LEGO® building workstation, Olivia takes the feedback board by herself and the school assistant asks, "What did you like?" and at the same time Olivia says in a clear voice, "I liked it a lot!" The school assistant confirms, "You liked it a lot." Olivia then attaches the photograph of the workstation under the happy face and says again, "I liked it a lot." (Transcription of a video data clip, February, 2012)

Overall, the majority of the children's feedback at the workstations was positive. This may indicate that the development of the learning environment succeeded well. On the other hand, not all of the children's feedback was positive. For instance, if there were technical problems with the applications, some of the children gave negative feedback, sometimes even spontaneously, by pointing to the sad face on the feedback board, as the next example illustrates.

> Iris immediately moves her finger straight back on the sad face. She points at it several times until the researcher names the picture, "I didn't like it." Iris then leaves the feedback board and takes the session map into her hands. (Transcription of a video data clip, April, 2012)

Regarding children's inclusion in the modification process, their overall participation in the development of the project's technology-enriched environment got stronger during the project. However, their participation was still limited. Therefore, the need to develop more elaborate means of participation remained to be solved in the future. Since the children did not give verbal reasons for their feedback, we did not know what precisely they were rating. They may have evaluated the station as a whole, a certain task or game, succeeding at a game or, for instance, creating a story, or interaction with the adult. The children's feedback used in this study served, nevertheless, as a good starting point for increasing children's participation in the development process, since it is unusual for children with ASD to be involved in the evaluation of their learning environments.

The researchers also improved the environment by interviewing the teachers and school assistants and taking their suggestions into account in technology modifications. The teachers' and assistants' contributions were important in developing the pedagogical contents of the applications and the environment as a whole. Although the teachers' and school assistants' suggestions were good and many-sided, most were rather difficult to implement at the school without extra technological support; therefore, the teachers' and assistants' participation in technology modification in practice must be developed. The next examples illustrate suggestions by teachers and school assistants.

> Iris would benefit if she had a building plate at the LEGO® building workstation and models of figures with only three or four blocks. She likes birds, for instance. (An idea from Iris's teacher and school assistant, written down in April, 2012)
> There could be a task with matching capitals with lower-case letters at the symbol matching workstation. (An idea from Ian's, Olivia's, and Eric's teachers, written down in April, 2012)
> The Feelings task at the symbol matching workstation could be modified so that there would be both drawn pictures and photos. After the tasks are completed, there could be a smiling face or a picture of a thumb up or clapping hands enclosed with the applause sound. (Ideas from the school assistant in Eric's class, written down in April, 2012)

The technologies' modifiability relates to the fourth principle in the establishment of a learning environment: the transformability of technological solutions to everyday life contexts. The feedback from the children and adults participating in the study indicated that technologies had to be easy to use for both children and adults in order to be truly transformable to a school context. For example, if the application was too complex, the adult was not able to tutor the child on how to use the application appropriately or help the child perform the task purposefully. In addition, using only pictures in the applications did not seem to be informative enough to explain the task's purpose. According to the data, clear instructions minimized the need for teachers and school assistants to obtain support from technical experts or task designers, and prevented misunderstandings in the usage or technology content. It was also helpful if the instructions were in sight in the tasks and games themselves, and not hidden somewhere in the menus. The availability of written language was also found important since some of the children learned to recognize written instructions while working with the technologies. This, in turn, increased the technologies' advantages considering the school context.

## 4.5 Conclusions

The purpose of this study was to present principles related to children's activity, creativity and strengths, and the technology's modifiability and transformability for the establishment of a strength-based technology-enhanced learning environment with and for children with ASD, as well as to introduce results on how the project succeeded in actualizing the principles in relation to children's actions in the learning environment. The findings indicate that the technology-enhanced learning environment introduced in this paper provided many opportunities for facilitating the emergence of potential skills, active participation, and the learning of children with ASD. In addition, the strength-based environment facilitated a chance to see the children's strengths rather than their challenges and to find diversified ways of supporting their learning. The modifiable and transferable technical solutions also facilitated individualized learning and teaching, thus increasing the possibility of the children's inclusion both in the school context and in society.

As technology plays an increasingly important role in children's lives in modern societies, children who are left out of this process are in danger of being disconnected from peers, cut-off from various opportunities, disadvantaged, and unskilled in terms of future work (Montgomery 2007, p. 210; Vicente and Lopéz 2010). It is crucial that technologies are continuously modifiable according to the interests, strengths, and needs of children with special needs, including autism. To meet the criteria of children's various situations, learning environments should contain multiple technologies. Every part of a learning environment should be taken into account: the people, the technologies, and the pedagogy.

Technologies should be developed with children with ASD, not just for them. Every child is entitled to an opportunity to make choices and affect their environment. It is crucial to establish multiple ways in which children with ASD can provide feedback and truly participate in the modification and development of technologies. Some recent studies (see López-Mencía et al. 2010; Nissinen et al. 2012) indicate that participatory evaluation, design, and development of technologies are possible for children with different special needs, including autism. An environment with multiple technologies provides a challenging yet promising starting point for participatory design. Since technologies interest children with ASD, the aim of the near future is to develop technical solutions that facilitate and diversify the children's inclusion in the development of their learning environments.

The transformability of technological solutions to everyday life contexts also calls for the involvement of all participants in the development process. Knowledge of the technologies and skills to use them in various ways increase the possibility that school personnel could also use technologies in everyday school contexts. As this study's results indicate, applications have to be easy to use and modify, from the viewpoint of both the children and the adults.

Although the results are very promising, there are several limitations in this study. The emphasis of this article was on describing the establishment of the learning environment and its technologies and on the research's overall results, instead of focusing on an exact research area. The number of participating children was low, which has an effect on the generalizability of the results; however, the project's learning environment worked as an experimental environment and the results can be further studied. Future research will give more detailed information about the actions of children with ASD, and the benefits and limitations of the project's technology-enhanced learning environment.

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