Identifying Design Sensibilities When Designing a System For a Special Needs Classroom

Hallum, Peter
IT Bachelor
Aarhus University
peter91@post.au.dk
201205401

Kruse, Michael M.
IT Bachelor
Aarhus University
munk91@post.au.dk
201205376

Larsen, Christian S.
IT Bachelor
Aarhus University
skyum91@post.au.dk
201205407

Thomsen, Matias R.
IT Bachelor
Aarhus University
milt1337@post.au.dk
201205408

ABSTRACT - ENG
This paper explores which design sensibilities are important to investigate when designing systems for children with learning disabilities in special classes. We do this by testing different design sensibilities in a special class, in order to investigate how they affect children with learning disabilities. We designed a digital school schedule for use in classrooms for special classes. The system, named EasySchedule, is designed to keep children updated on the progression of their school day. By testing the system in a special class, we learned how different design sensibilities affect children with learning disabilities. We found that the following three design sensibilities are especially important: perception of colors and pictures, flexibility, and unobtrusiveness.

ABSTRACT – DAN
Denne afhandling udforsker, hvilke designovervejelser det er vigtigt at undersøge, når man udvikler et system for børn med indlæringsproblemer i specialklasser. Vi har testet forskellige designovervejelser i en specialklasse for at udforske, hvordan disse påvirker børn med indlæringsproblemer. Vi har bygget et digitalt skoleskema til at stå i klasselokalet. Systemet, EasySchedule, er bygget til at holde børnene opdateret med skoledagens forløb. Ved at teste systemet i en specialklasse har vi lært, hvordan forskellige designovervejelser påvirker børn med indlæringsbesvær. Vi fandt, at følgende tre designovervejelser er særlige vigtige: opfattelse af farver og billeder, fleksibilitet og distraktionsniveauet.

ACM Classification Keywords
Design; Human Factors;

1 INTRODUCTION

In recent years, an increasing number of children are being diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) in tandem with other learning disabilities [12]. These disabilities complicate learning and require extra attention and care from teachers and psychologists. Children with learning disabilities are often taught in separate classes because they do not fit in a normal classroom environment. This is because most elementary schools apply the constructivist approach developed by Jean Piaget [14]. The constructivist approach requires the learner to be active in the learning process, have a strong short-term memory, have the ability to integrate knowledge, reflect upon new knowledge, and find motivation for learning. These requirements conflict with the typical symptoms of children with learning disabilities, which often includes lack of attention, lack of motivation, poor short-term memory, lack of concentration and difficulty in integrating new knowledge and reflecting upon this.

From conversations with a social pedagogue, that teaches a class with special needs children, we learned that an ordinary special needs classroom is stripped of everything but the essentials as not to distract the children. The only items allowed on his classroom walls are a smart board, pictograms visualizing the school day, a traffic light letting the children know when they are allowed to talk, as well as a traditional analog clock. With the growing advancements in physical computing and computer-aided tools, we wish to investigate if any technology-embedded tool placed in the classroom can create a better environment for the children to learn and thrive. We learned from a psychologist at Aarhus municipality that structure is of high importance for the children during their school day, and if the structure starts to fade so does their focus. One of the tools used by teachers are pictograms illustrating the class schedule, so the pupils know the schedule of the day. This is helpful for children with e.g. ADHD, since their sense of time is significantly worse than that of a child without special needs [1]. However, since a child with learning disabilities struggles with time, they have difficulty using an analog clock. This causes the children to ask the teacher or check their phone to orient themselves of the time, which can cause distractions for all children. A motivation for the project is to visualize the flow of the day so a child with learning disabilities can comprehend time better, and be able to put time into the context of what they are doing at a certain point and for how long.

This paper investigates which design sensitivities are relevant to comprehend and take into account when designing for a classroom environment for children with learning disabilities. We created a rolling school schedule, which visualizes the next two hours of the children's schedule, i.e. to inform the child about the next break (see Figure 1).

We try to explore how to answer the research question through several iterations of testing the system in a special needs classroom setting. After each iteration, the details of the design requirements expanded. The empirical data gathered from the evaluation is then presented and discussed.

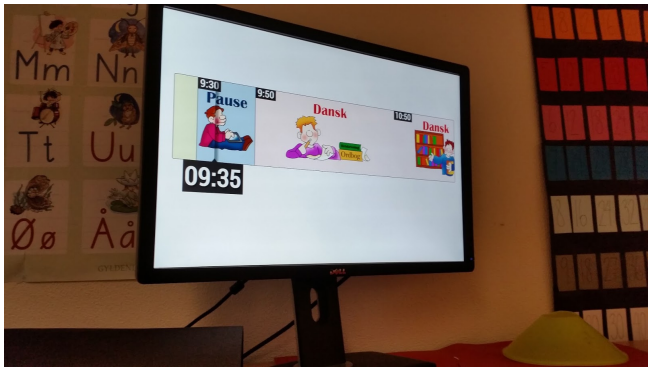

Figure 1. View of the system setup in a classroom for evaluation

The main results from our study show that certain design sensitivities are important to examine when designing for a classroom environment for children with learning disabilities. These design sensitivities are perception of colors and images, flexibility, and obtrusiveness. In our experience, these three guidelines are important to consider when designing a successful system or prototype for a special needs classroom.

2 RELATED WORK

We have studied several articles or works that we consider relevant to our process. The related work deals with different topics including learning disabilities in general, designing for learning, and systems or prototypes designed to assist children in learning. This kind of technology is frequently called assistive technology, as it assist individuals in reducing the impairment of their disability.

Sajadi & Khan describe the constructivist theory applied in most elementary schools to teach children. The theory, which Jean Piaget developed in 1954, describes how people learn in practice [14]. The constructivist approach does not fit well with children who have learning disabilities because it requires the learners to stay motivated, focused, and be able to integrate new knowledge with already existing knowledge. These required skills conflict with the abilities of a child with a learning disability. This insight is essential knowledge in relation to our research.

Król-Gierat describes the symptoms of ADHD, and aims to investigate the performance of individuals with ADHD in a multimedia-learning environment [12]. The article concludes that the effectiveness of multimedia depends on how it is applied. Cognitive overload coming from multimedia, combined with the school demand to retain different information at the same time, can lead to slower responses and lower accuracy performance for ADHD children. On the other hand, the use of multimedia has proved to be effective if properly conducted. The article is relevant because of its detailed description of ADHD.

Tse et al. and Preston & Mowbray explore the use of larger displays in the classroom as Smart Boards have become increasingly popular in the last decade. Tse et al. lists several key-factors to keep in mind when designing interfaces for children [15]. First of all, children do not have a fully developed cognitive memory load, nor do all have good literacy skills. Preston & Mowbray present the findings of classroom-based research with a kindergarten class [13]. They conclude that the use of smart boards motivate children. Additionally the results show that kindergarten pupils need fewer instructions to learn to use the smart board, as opposed to handwriting with pen and paper. These results are relevant to our work as the articles deals with similar environments and settings.

Karimi et al. describe the development of a prototype called *Time-Me*, a tool to help children understand the concept of time [11]. Children may be able to read what time it is by looking at an analog clock, but they have difficulty sensing time and knowing how much time has passed. This goes especially for children with ADHD pursuant to Barkley et al. [1]. Therefore *Time-Me* uses a tangible user interface in order to give children a better correlation between reading and understanding time. The research presented in this paper is of high relevance to our project because we partially are trying to achieve the same goal; representing time in a more child-friendly way to give children a better sense of time. Karimi et al. have tried to visualize time with a tangible user interface (see Figure 2).

Figure 2. Blocks of different sizes and colors that visually represent time duration.

TimeTimer is a product that helps children understand time. Children often have trouble sensing time and analogue clocks can be hard to understand [1, 10]. The digital clock often appears as random numbers changing with no way to envision time as a measurement. *TimeTimer* helps children see time as a measurement as they can see time pass. *TimeTimer* can be set to an arbitrary time interval, e.g. 30 minutes for a school assignment, and then it shows visually how time passes. This enables the child to see how much time remains without being demotivated by the fact that they do not understand time very well. This is relevant to our research as we try to address the same challenge in special classes in order to help the children stay motivated during classes. *TimeTimer* is designed to help children un-

derstand time and how it passes, and this motivated us to use visualization of time as a tool to help children understand time. Our product differs from *TimeTimer* as we use a digital schedule to visualize the flow of time as opposed to *TimeTimer*, which uses an analogue clock (see Figure 3).

Figure 3: Time Timer

Cramer et al. developed a classroom-based assistive technology called *vSked*, an interactive and collaborative system for students with autism [4]. The system consists of a large touch screen in front of the class controlled by the teacher, and individual devices for each student in the classroom. The system combines the already existing visual schedules, choice boards, and a reward system into one device. As this system is somewhat comparable to ours in visualizing the daily schedule, it is interesting to compare their process and methodology to ours.

Hasselbring & Glaser describes how the use of computer technology can help students with special needs [9]. Students with learning disabilities and emotional problems account for nearly 60 percent of all children who receives special needs services in schools. Research shows that the use of computers enhances a student's ability to acquire new skills and knowledge when the computer is used to deliver well-designed and well-managed instruction. As an example, the use of word prediction software can help children with learning disabilities to compete academically in a regular classroom setting. Multimedia environments are also helpful for children with learning disabilities. It can aid the students' conceptual understanding by linking images with sound effects to information that is hard to understand when presented with text alone. This article is relevant to our research because we are using computer technology to help children in special classes. The research shown in this article emphasizes that computer technology can help students with special needs if the system delivers well-designed and well-managed instructions. Quenneville describes a collection of different tech tools for students with learning disabilities, the benefits these tools may offer the students, and the role technology could or should play in inclusive classrooms [16]. In perspective to our research, Quenneville concludes that the use of tech tools in classrooms with learning disabled students can be one way of breaking down barriers to learning.

Not all classrooms for learning disabled children are equipped with assistive technology even though it appears useful and supportive. Copley & Ziviani have analyzed a collection of papers in order to identify the barriers hindering an effective integration of these technologies in classrooms [3]. The barriers include lack of appropriate staff training and support, negative staff attitudes, inadequate assessment and planning processes, insufficient funding, difficulties procuring and managing equipment, and time constraints. Developers must therefore consider how to remove these barriers when designing assistive technology for a classroom, as integration of the technology is likely to improve learning. This is beyond the scope of our project as our system has very basic functions, but it should be taken into account if the system is developed further.

Edyburn describes the problems and challenges associated with the use of assistive technology and criticizes some common views concerning holding back assistive technology from children [5, 6]. Edyburn compares the need for assistive technology for children with mild disabilities versus children with physical disabilities e.g. blindness. He points out that the school system is not good at identifying needs for assistive tools. As an example, nobody would question a blind person getting a tool for reading texts out loud, but giving an assistive tool to a child diagnosed with ADHD would be seen as cheating or hindering his or her ability to learn. The paper lists a number of assistive tools for different challenges such as poor decoding of text or poor memory. Edyburn underlines the importance of identifying the disability in order to intervene with the right tool. Similarly, our paper also researches different sensibilities for designing an IT system for learning disabled according to identified needs.

Friedman's essay in the New York Times from November 2014 presents a slightly provocative point of view on ADHD in society today [7]. He writes that ADHD has become the most prevalent disease among American children as 11% between the age of 4 and 17 are affected by it. Friedman writes that people diagnosed with ADHD will not achieve the same amount of stimulation from everyday activities as healthy people do. As a result they become bored and under-stimulated, leading to the behavior and symptoms you would normally relate to ADHD. This behavior often includes seeking new and exciting experiences, getting impatient, becoming restless and demotivated in the structures of modern schools. The latter is relevant to our

research, but the article does not describe the issue from different perspectives.

3 RESEARCH QUESTION

3.1 Main-question

What design sensitivities are relevant to comprehend and take into account when designing for a classroom environment for children with learning disabilities?

3.2 Sub-questions

- What are learning disabled children's main challenges in the classroom?
- How can we ensure that digital systems remain helpful without being obtrusive?
- How can time be visually simplified to enhance learning disabled children's sense of time?
- How can a digital representation of a school schedule affect children in a special class?

4 BACKGROUND INTERVIEWS

This section presents the collected empirical research regarding children with learning disabilities. The data is primarily collected through semi-structured interviews with: Lotte, psychologist at Aarhus municipality; John, social pedagogue at elementary- and middle school Sølystskolen; Bruno, teacher at the special needs school Langagerskolen; and Selma and Sofie from center for ADHD. We never interviewed children during our empirical research. There are two reasons for this: We felt that adults, who work with children with learning disabilities on a daily basis, can provide us with more usable knowledge and because it is difficult to get permission to interview children in Denmark - especially children with special needs. One of our interviewees, John, agreed to test and evaluate our final system with his class consisting of six special needs children. During our empirical data gathering, we collected information concerning different design aspects, which we will present in the next sections.

4.1 Understanding the children in special classes

According to John, many children with ADHD have a parent with the same disability, or a parent that fails to understand the need for routines and structure. When the parent's ADHD causes the household to lose structure, this affect the child in a negative way. Parents, who fail to wake up the child in time for school, and run everyday life with many spontaneous choices, will often cause the child's ADHD symptoms to worsen.

Some pupils from John's classroom speak two languages thereby implying that one or both parents are from a foreign country. This means that they could be challenged at home because their parents were unable to help them with homework. Because of this, and the fact that they never did their homework anyway, the teacher of this class did not assign them homework at all.

According to Lotte, many of the problems related to children with learning disabilities derive from their environment and a loss of structure both at home and at school. Research shows that their symptoms lessen, when their daily life becomes more structured.

4.2 Classroom leadership

Lotte stated, that the children often have difficulty learning how to structure their daily life on their own and they do not know how to act in a classroom once class starts. Therefore, it is important that the teachers be well prepared for class in order to inform the children of the day's plan. It is important to take them through the day and go through every step, as well as making sure the children know exactly what they are supposed to do. Lotte refers to this as *classroom leadership*. John also stressed that the main challenge for the pupils is to remain focused during the whole class. A newly added optional tool at Sølystskolen is the use of iPad's during class. According to John, the multimedia opportunities have great potential if used correctly, but can easily become obtrusive.

Figure 4. Shown is the traffic light (left) and the daily pictogram (right).

4.3 Design challenges

Multiple key factors need consideration when designing digital systems for implementation in a classroom. One important factor is that the system is not attracting too much attention from the pupils. This applies to several aspects of the design. When designing digital implementations to a classroom, animations have to be used with care in order not to remove focus from the lesson. John stressed this point explicitly. Furthermore, the pupils have an existing understanding of some colors. Sølystskolen is currently using an analogue traffic light (see Figure 4). The three colors; red, yellow and green, indicate the current behavior allowed in class. The red color indicates that the pupils are not allowed to disturb each other and should work alone. The yellow color indicates that the pupils can ask questions and the green color states that talking is allowed. For this reason, it is important to use colors with care, as children perceive colors in different ways. They associate certain colors with positivism and negativism. Bright colors, e.g.

pink, blue, and red, are for most children associated with positivism whereas darker colors, brown, black, and grey, are associated with negativism [2].

Another important factor is that the design requirements often vary from class to class. John stated that what works in his class might not necessarily work in other classes; it dependents on the pupils, because they all have different mental disorders in special classes. What works for pupils with ADHD is not likely to work for pupils with autism or Down's syndrome.

5 DESIGN PROCESS

Based on the findings of our empirical research, we identified that creating structure had to become one of the more significant areas of focus in the design process. The daily pictogram of the school day used both at the special class at Sølystskolen and at Langagerskolen was the initial inspiration for the brainstorming process (see Figure 4). We came up with an idea to make an electronic pictogram. However, a problem with this idea was identifying the value added to the classroom by embedding it with technology. In dialogue with John, we concluded that a digital version did not provide any additional value and therefore we decided to investigate the matter from another perspective.

Another finding from our empirical research and related work showed that the children had difficulty sensing time and this was one of the main challenges for staying focused during class. We were inspired by the research described in Karimi et al. and Barkley et al. [11, 1]. In the first article, the goal is to make a product that can help children improve their sense of time, which is the same thing we are doing albeit with a different target group and context. In the latter article, they explain how children with ADHD sense time a lot slower; children without ADHD intuitively have a better idea of how long five minutes is as compared to children with ADHD. In the classroom setting, this leads to stress and confusion. We wanted to use their results concerning visual representation of time in order to design a digital system that can help the children understand how far they have progressed in the current school day. Through brainstorming and the findings in the two articles, we came up with the idea of creating a visual representation of the daily schedule, to replace the analog clock as well as supporting the already proven methods of pictograms used in the schools.

We made a low fidelity prototype, and in collaboration with John, we discussed our first iteration of the prototype. The idea was well received and John provided us with useful feedback for improvements. The interval of approximately two hours was ideal. It gave the children something to look forward to (a break or the next activity), but did not make the day seem too long and overwhelming. However, John suggested that we removed some of the colors to avoid taking too much attention from the lesson (see Figure 5). John also felt this idea could make the pictograms he currently uses obsolete, if we added an all-day-view. Then the teacher would be able to present the schedule for the whole day, before switching the view to the current lecture.

Finally, it was necessary to smooth the visual transition from one lecture to another. There cannot be a distinctive color switch when the class switches from e.g. math to history. The reason for this is that the subject class we used for testing had a boy with autism. If the color transitions were contrasting or drawn up by a black line, he would get frustrated if the teacher did not switch the topic of the class at the exact time the timer passed the transition. This is important to take into account, as delays often occur in a special class.

We wanted to create a system that was easy to implement in a classes so we decided to make it as a web application with HTML and CSS. This solution is flexible and easy to run in any web-browser on any screen or computer connected to the Internet.

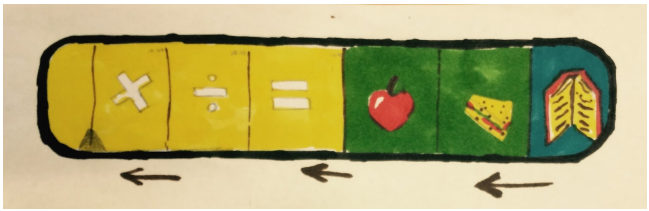

Figure 5: Low fidelity prototype

6 CONCEPT

We designed a digital school schedule for integration in special classes. The system design aims at keeping children with learning disabilities updated on the progression of their school day. By doing this, we wish to help the children stay focused and motivated throughout the day. This is done by visualizing the schedule with image blocks that displays the current lecture (see Figure 6). Furthermore, the blocks are sized accordingly to the length of the lecture. As the day advances, the schedule progresses horizontally and thereby shows when the lecture is done, and what happens next. This way the children can always see how far they have progressed during the day, and when the next break is. This helps the children stay motivated, as the pause is a rewarding factor that functions as a motivation for the children.

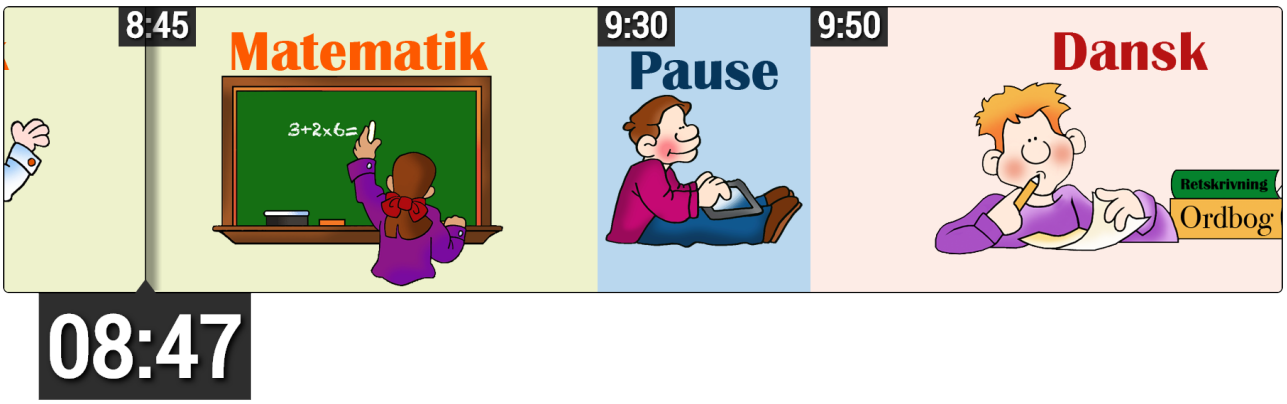

Figure 6: The image blocks showing the current lecture and the upcoming break

Furthermore, we implemented a feature for the teachers to add notes to the blocks if they wish to add more information to the class. The teachers can also timeout a lecture, which will stop the schedule from progressing until it is resumed. Lastly, the teacher has the ability to show a view of the entire day to introduce the children to the upcoming day.

The system we made is relatively simple. This is a conscious design choice, as mentioned by John; it was a key factor to ensure that the system remained unobtrusive. This relates to the colors and the animations used.

7 EVALUATION

7.1 Methodology

The system has gone through several iterations ranging from low-fidelity mock-ups to high quality functioning implementations represented on a 24-inch screen. The iterations enabled us to analyze different design sensibilities.

Before the actual evaluations in a natural setting, the early mock-up drawings and sketches of the concept had been evaluated with the special class pedagogue, whom we agreed to test the high-fidelity prototype with. His daily experience and understanding of the environment was relevant to evaluate the early concepts.

Several weeks later after developing a high-fidelity system, we had another meeting with him, and planned how the final evaluations were going to take place. We thoroughly explained which aspects and change of behavior we would like him to observe in the classroom, but we also stressed that anything interesting or unexpected was worth noting.

The specific special class we used for testing had six children. They had all been diagnosed with a learning disability or had symptoms of ADHD, except one who had autism. The testing and evaluation was completed in two days a week apart, giving us a week in between to add to and upgrade the system according to the feedback we received. We placed the system in a corner of the class on a shelf, with a computer connected to a 24-inch screen showing the animated school schedule for the whole day. In the breaks, we would get an update from the teachers in the classroom on the pupil's reaction, their understanding of the system, and potential effects on the classroom environment. At the end of the day, the teachers would ask the class what they thought of the system, and convey this information to us. We could not be present in the classroom to observe because of the sensitivity of special classes, i.e. it is already challenging to maintain focus and conflicts may easily arise.

The first iteration of the evaluation conducted at Sølystskolen rewarded us with a lot of feedback concerning both positive and negative aspects of the system.

Prior to the second iteration of testing, we implemented new features to the system. We added functions for the teachers to show a view of the entire day and some flexibility to the system in form of a function to timeout the system and a function to add notes to post information for the children.

7.2 Results

This section presents the results gathered by testing and evaluations. The results are presented chronologically and unedited. Therefore, some results may be contradicting.

The first iteration of testing yielded many results from several sources: The children, John and the teachers. The children voiced several ideas, thoughts and concerns about the schedule. They generally liked the visualization and looked at the screen quite often. A few of the children also noted that the system did not really do anything and they questioned the purpose of the system. A few had some additional comments to the system. One liked the display of the clock on the screen, whereas another child disliked it. One also thought the system displayed what the pupils already knew, the clock and the schedule. However, this should not be a long-term concern since the system should replace the clock and the original pictogram. One child said he did not notice the screen much at all and finally another child,

when asked about understanding the system, answered, that he understood the visual representation.

John and the other teachers offered their ideas and opinions as well. Some asked for functionalities that we subsequently implemented during the second iteration of testing. A positive thing was, that the system displayed when the class would be finished. They saw this as a major advantage and as a motivational factor compared to the original pictograms. Especially one child seemed to use the system a lot to orient himself of how far they had progressed in the current lecture. At some point, they had two Danish-lectures in a row, which looked almost unending on the schedule. This was demotivating for the children. The icon used for the Danish-lectures was confusing and lead the pupils to believe it was a library-session. John and the teachers also stated that they would like a timeout-function, which should fade out the current topic they are working on. This function would be needed to put a lecture on stand-by when they had to solve a conflict in the classroom. They asked for a visual representation of the whole day as well, so the system could completely replace the existing school schedule of Velcro pictograms. Finally, they expressed that they wanted to use a final implementation of the system, and that we might have discovered a need that they did not know existed. For the following iteration of testing, there would be a couple of functions to add, including correcting minor misunderstandings of some specific timestamps on the schedule.

The second iteration yielded few new results and findings. One of the children had asked in the previous week where the new system was. John had discussed the system with other social pedagogues, and they confirmed a need for the values and functionalities. He jokingly mentioned they wished to purchase the system for their class. The all-day view implemented for this week was showing the entire schedule a bit too fast. It should be slowed down or modified to always show the whole day. This was important to the children. The text used to add keywords to the classes should be with a smaller font so more words could be added. Finally, they wanted a more significant visual transition between the two Danish-lectures due to their lengths.

8 DISCUSSION

8.1 Analysis of results

The first high fidelity prototype of the school schedule used some symbols, which conveyed the wrong perception to the children. As an example, the image for a Danish lecture made the children think it was a library lecture. Perception of colors and images vary depending on culture, setting and understanding of an individual or a group of people. In our case, we interpreted a different meaning of a symbol than the children, which caused confusion. The only way to test this understanding is to evaluate the system in a pragmatic setting with the children, for whom we are designing the system. Furthermore, John mentioned on several occasions the necessity to avoid using sharp red, yellow or green colors because they could interfere with the understanding of the traffic light already in use. He also mentioned to avoid using too reddish or yellowish colors since the class only had boys. We evaluated this issue, and it showed not to be a problem. This confirms that perception of colors and images is an issue that requires actual user testing.

Suggestions of a more flexible system were proposed from the first to the second evaluation. The result of this was the timeout function as well as the functionality for adding notes to each class. By testing our system, we identified flexibility to be an integral part of designing for a special needs classroom. This is due to the unexpected nature in the classroom. Often problems arise, which delay the next lecture because they have to discuss the issues in the class. Sometimes the teacher decides on a small break if the children are becoming too rowdy. Because of this, it is important that the system can handle such sudden changes. Another value from the time out function is to deal with autistic children, who are very fussy when the timer goes from one lecture to another. For these reasons, a system for special classes needs to be flexible.

Designing a system to help special needs children improve their focus by helping create structure, can easily lead to the opposite, if the system becomes too obtrusive. EasySchedule is deliberately designed not to demand too much attention in the classroom setting. Too many bright colors or animations can cause the children to become distracted from their assignment. This is counterproductive towards the goal of helping the children. Instead, we aim towards a neutral design, which the children can use on their own terms. In the classroom we evaluated, John had carefully planned the layout. It consists of four pedagogical tools to create the right environment. If the classroom becomes too crowded with objects, this too will have an obtrusive effect on the class. For this reason, we designed our system to help clear the classroom instead of adding more elements to it. The goal is to make the analog clock replaceable with our system. Later in the evaluation, we even experimented on replacing the pictograms by adding the all-day view to the system. Once again, we carefully planned how to implement these features without removing the element of being unobtrusive.

Perception, flexibility, and unobtrusiveness are three key aspects to keep in mind when designing a system for a classroom environment for children with learning disabilities. If a system fails in one of these aspects it can possibly reduce the quality of the classroom environment and the children's focus. General principles for designing a system are still applicable but perception, flexibility and unobtrusiveness must be prioritized.

The three principles correlate to one another. For instance, if we were to bring our time scheduling system into a different special class, the perception might differ depending on e.g. what lectures they have and whether they are using different pedagogical tools. By extending the flexibility of

the system and adding a client-side, the teacher could customize symbols and colors for each individual special class. This would also improve the perception of the system. Both bad perception and lack of flexibility also add to the unobtrusiveness of the system. This is something we noted with the badly chosen symbol for the Danish-lecture, which became distracting for the children.

One of the more rewarding parts of the evaluation with John and the special class at Sølystskolen was the interest they took in our project. As stated in the results section, John told us several times, that he acknowledged the values and functionalities of the system we developed for the class. He stated that it needs refinement but also that it has great potential. He even discussed the concept idea with other social pedagogues, which we saw as a genuine interest from his side. We were also happy to discover how eagerly the class was trying to incorporate the system into their regular school routines. Some of the ways they used the system came as a surprise to us. They noted, for instance, that the font of the notes were too big. At first we did not understand why this would be a problem, but we realized it was because they wrote down the assignments and activities they were doing, and they were too long to fit on the screen.

8.2 Strengths and weaknesses of the study

In this study, we have had an empirical data triangulation with interviews from a social pedagogue, a teacher, and a psychologist. We also collaborated with a social pedagogue at Sølystskolen for several weeks. This provided us with knowledge and insight into how children with learning disabilities function on a daily basis. The class we investigated only had six children, and pupils in special classes differ from class to class. We have only tested the system in one special class on two occasions. In order to evaluate how our system helps and effects the children we would need to test it in several classes over a longer duration. The proposed design sensitivities are based on empirical research and testing in a Danish school.

During the tests at Sølystskolen we were not able to observe how the children reacted to the system. The feedback we received was second hand from the social pedagogue; we asked the pedagogue to look for certain aspects of the design and behavior, but we might have missed important feedback.

8.3 Contribution

The main contributions of this paper are guidelines to consider when designing a system or product for a special class environment. The three primary things to consider are perception, flexibility, and unobtrusiveness.

Perception covers the choice of color, images, and shapes. You should avoid sharp colors because children may have an interpretation of these, either if they are already used by other pedagogical methods, or if some children dislike them. Images need to be easily understandable and should communicate the exact purpose. *Flexibility* means that a system or product should be able to adapt to changing conditions. In special classes, conflicts can arise quite often, and thus it should be possible to remove attention from a product or system, or adapt it to the new situation. The teacher or pedagogue should be able to do this easily. Finally, a system or product should be *unobtrusive*. Children with learning disabilities are already challenged with staying focused, and therefore it is important to avoid making something that is either obtrusive or distractive.

The three terms are correlated in many situations. If perception of the system is poor, it could likely be obtrusive as well.

8.4 Research question & answer

In order for us to answer our primary research question, we begin by answering all of the sub questions.

What are learning disabled children's main challenges in the classroom?

Children in special classes usually have some sort of learning disorder in various degrees. An example of a learning disorder is ADHD. Children diagnosed with ADHD are challenged in their ability to stay focused for longer periods, remain calm for longer periods and integrate new knowledge acquired with old knowledge attained earlier. These symptoms make it very difficult for them to thrive properly in the modern elementary- or middle school, because they are based on the constructivist theory. The constructivist theory requires the pupils to motivate themselves and actively seek to learn new knowledge.

How can we ensure that digital systems remain helpful without being obtrusive?

Two days of product testing did not generate enough data to determine if our system fulfilled this, but we should be able to answer the question based on the empirical data obtained during interviews. We understood that digital products easily became too distractive in the classroom. Examples of this are smartphones and iPads used in the classroom. The children were allowed to look at their smartphone to note the time, and they often used iPads as they were allowed to hear music in headphones. We understood that this probably reduced their performance. So when designing digital systems for a classroom it is very important to avoid it becoming a distraction as the children are already challenged in focusing on getting their work done.

How can time be visually simplified to enhance learning disabled children's sense of time?

There is no certain answer to this question, but the system we developed has a more visual approach, which should replace the analog and/or digital clock in the classroom. We do know through our empirical research that most children in special classes cannot read analog clocks. Therefore, the system could be a suitable way to illustrate the clock and the progress of the day. We did this by combining the

blocks visualizing the length of each class with a digital clock presenting the current time.

How can a digital representation of a school schedule affect children in a special class?

Initial feedback was positive and we believe that a further developed system would be suitable for the children. The mixture of a clock and the normally used pictograms could enhance their ability to understand how far they have progressed in the daily schedule, and thereby motivate themselves more in order to learn. We realized that using the system is a learning process for both the children and the teachers. They have habits in how they orient themselves of the time, so in order to discover the effect of the system we would need to test the system in a longer period.

Finally, the main research question says; *what design sensitivities are relevant to comprehend and take into account when designing for a classroom environment for children with learning disabilities?*

As outlined in the previous section (Contribution), there are three primary design sensitivities to consider when designing for a classroom environment with children with learning disabilities. These three design sensitivities are *Perception, Flexibility, and Obtrusiveness*.

8.5 Future research

It is relevant to test how the system affects children in other special classes. It would also be interesting to test the system abroad in a setting with a different culture to see how the perception may vary culturally. We would also have liked to test the system in a regular class in order to investigate if any of the systems design sensibilities had an effect. The development is based on empirical research regarding children with learning disabilities, but some of the design sensibilities might also apply to regular classrooms, thus potentially opening up for a new research area.

If more time had been available, we would implement a back-end to support the flexibility of the system. This flexibility would help the teachers customize the system to the children's specific needs: pictures, colors, notes, etc. It should be editable from a web-browser.

It would also be interesting to test if the system could synchronize with schedules online enabling classes to implement the system through an online update to specific class schedules. This would add to expand the system, as it would be easy to implement in new classes and schools.

Furthermore, we would have liked to make a screen with the correct size. We used a 24-inch monitor with a 16/10 aspect ratio in our testing at Sølystskolen, but it would be interesting to test the system on a more oblong screen size with a 16/5 aspect ratio. This would provide the children with a better and a more precise feedback. The schedule would progress through the school day at higher speed as the interval of two hours would be larger scaled.

It could also be interesting to test if the children would prefer having the schedule on a different media such as smartphone, which are increasingly being used in schools. The entire class should not be forced to use the schedule this way but it could be offered as a voluntarily option.

9 CONCLUSION

This paper investigates what design sensitivities are relevant to comprehend and take into account when designing for a classroom environment for children with learning disabilities. To investigate the matter we collected empirical data and information through interviews with a psychologist, teacher and several social pedagogues. We also established collaboration with a social pedagogue at Sølystskolen. He evaluated the different iterations of our system in his special class for children with learning disabilities to test how different design sensibilities affected the children. The design sensitivities we have found to be the most important to examine before developing new systems for children in special classes are *perception*, *flexibility* and *obtrusiveness*.

10 ACKNOWLEDGEMENTS

We would like to thank Robert and Tobias for their great feedback and support throughout the process. We would also like to thank Selma, Sofie, Bruno, and Lotte for their time and insight. Lastly, special thanks to John at Sølystskolen for his continued help with testing the system and for giving feedback on our product iterations.

11 REFERENCES

1. Barkley, R., Koplowitz, S., Anderson, T., McMurray, M. Sense of time in children with ADHD: Effects of duration, distraction, and stimulant medication. *Journal of the International Neuropsychological Society*, 1997, 359-369
2. Boyatzis, C. J., Varghese, R. Children's Emotional Associations With Colors, *The Journal of Genetic Psychology: Research And Theory on Human Development*. Volume 155, Issue 1, 1994, 77-85
3. Copley, J., Ziviani, J. Barriers to the use of assistive technology for children with multiple disabilities. *Occupational Therapy International*, 2004, 229-243
4. Cramer, M., Hirano, S. H., Tentori, M., Yeganyan, M. T., Hayes, G. R. Classroom-Based Assistive Technology: Collective Use of Interactive Visual Schedules by Students with Autism. *CHI 2011*, Vancouver, BC, Canada, May 2011, 1-10
5. Edyburn, D. L. Assistive Technology and Mild Disabilities. *Special Education Technology Practice*, 2006, 18-28
6. Edyburn, D. L. Rethinking Assistive Technology. *Special Education Technology Practice*, 2004, 16-23
7. Friedman, R. A. A Natural Fix For A.D.H.D. *The New York Times,* 31/10/14, 1-6

8. Geary, D. Mathematics and Learning Disabilities. *Journal of Learning Disabilities*, 2004, 4-15
9. Hasselbring, S. T., Glaser, W. H. C. Use of Computer Technology to Help Students with Special Needs. *The Future of Children, Vol. 10, No2, Children and Computer Technology*, 2000, 102-122
10. http://www.timetimer.com/explore-education.php
11. Karimi, A., Liang, B., Nip, A., Nowroozi, S., Pang, C. Time-Me: Helping Children Understand Time. *IDC 2012 Short Papers*, 2012, 268-271
12. Król-Gierat, W. Individuals with Attention-Deficit Hyperactivity Disorder in a Multimedia Learning Environment. *Journal of Multimodal Communication Studies Vol. 1*, 2014, 33-41
13. Preston, S., Mowbray, L. Use of SMART Boards for teaching, learning and assessment in kindergarten science. *Teaching Science, Volume 54, Number 2*, 2008, 50-53
14. Sajadi, S., Khan, T. An Evaluation Of Constructivism For Learners With ADHD: Development Of Constructivist Pedagogy For Special Needs. *European, Mediterranean & Middle Eastern Conference on Information Systems*, 2011, 656-671
15. Tse, E., Schöning, J., Rogers, Y., Shen, C., Morrison, G. Next Generation of HCI and Education: *Workshop on UI Technologies and Educational Pedagogy. CHI 2010 Workshops*, Atlanta USA, 2010, 4509-4512
16. Quenneville, J. Tech Tools for Students with Learning Disabilities: Infusion into Inclusive Classrooms. *Preventing School Failure: Alternative Education for Children and Youth*, 45:4, 167-170