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Difficulties of Screen Readers in Primary School Computer and Typing Education by Children with Visual Disabilities

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BACHELOR THESIS

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Abstract

With the changes of computer education in the Netherlands, a group of students that are affected by this change are children with a visual disability. Research has shown that problems with the use of screen readers exist, although literature in the specific context of primary school education is lacking. This study aims to provide a broad range of insights into the difficulties of screen readers in the stated context. Building on existing research, it asks: Which difficulties are faced with screen readers used in primary school computer and typing education by children with visual disabilities? Using existing work, a semi-structured interview guide was created, which was conducted with experts on the subject of assistive technologies within education. Analysis of the data found three main difficulties: additional load on students, inaccessible educational web content, and lack of awareness by publishers. Results show that the difficulties could impact the focus of children using screen readers, furthermore these difficulties could impact the accessibility of regular education for the group. Even so, it seems that most of the problems could easily be mitigated by greater awareness for accessibility.

Contents

1 Introduction

Over the last few years computer education has started to become increasingly relevant in the Netherlands, especially in primary school education[13]. This change is viewed as necessary to better prepare students for secondary school requirements and make the transition of educational content more seamless. The term used for both computer and typing education is digital literacy, a term that is not consistently used, but can be as seen referring to many different ICT-related skills, and is viewed as a core part of the Dutch curriculum. It is stated that more attention should be given to it in the future[14]. An important topic in relation to the rapid development of compulsory computer education, and in the context of laws and regulations, is inclusiveness. It is stated that an inclusive approach should be maintained to address the needs of minority groups, gender equity and special education needs[16]. An inclusive approach entails thinking about how certain content will probably engage girls more than boys and vice versa, and how the content should be aware of students with special needs and learning disabilities. As digital literacy is becoming a core part of the curriculum, any computer educational content used should be accessible for all students.

One group of students that faces a distinct challenge in accessing the computer educational content through traditional means are children with visual disabilities. It is known that in the Netherlands the majority of students from this group attend regular education. They face the challenge of needing assistive technologies to aid them in accessing the digital content. These children learn how to type, how to use a computer for basic searches, and how to use certain text and other editing programs like any other students. An important point to take into account is the fact that, because of the nature of their disability, it seems likely that they will be reliant on, and suited to, digital technologies in their future professional careers. Any accessibility problems between assistive technologies and the educational content is therefore a cause for concern. Not only is this beneficial for their future careers, it will also enable them to participate in regular education.

One important assistive technology used by children with a visual disability to access digital content is the screen reader. This software tool is used to navigate virtual environments that are normally displayed on a monitor or display. The software uses text-to-speech and other non-visual forms of communication like braille to attempt to convey what is shown on screen. These tools are very sophisticated and support a large set of options ranging from choice of language and voice to different forms of braille scripture. The inherently text-based nature of computers should provide easy conversion for the use of screen readers in computer education. Nonetheless it is known that difficulties with accessibility exist in using screen readers to view and use certain types of e-learning content[3]. It is also not yet clear what these problems entail in the broader context of primary school computer and typing education and children with visual disabilities. This research tries to provide insights into these problems with the following research question:

Which difficulties are faced with screen readers used in primary school computer and typing education by children with visual disabilities?

1.1 Thesis overview

This chapter contains the introduction. In chapter 2, prior relevant work is reviewed. Chapter 3 describes the method used to perform the research. After this the results are provided in chapter 4, which are discussed in chapter 5 in addition to further work. Finally a conclusion is given in chapter6. This bachelor thesis was part of the PERL group at LIACS, made possible by the support of Anna van der Meulen and Felienne Hermans.

2 Theoretical Background

2.1 Primary school education

For primary school education, the use of many kinds of computer hardware and software for educational purposes is something that has been researched thoroughly[7][8]. These sorts of educational content are already being implemented, as mentioned by Duncan and Bell[6], Computer Science and programming are being introduced into primary school curricula to equip students with Computational Thinking (CT) skills. This has also been researched on a broader scale in 2016, where the European Joint Research Centre (JRC) published a report[16] on the subject of CT, providing an overview of these skills and discussing significant developments for compulsory education in different European countries. In this report, it is described that the Netherlands has been having a wide scale debate about including CT into an existing core curricula subject, called Information Literacy. Here recommendations have been made to create new Digital Literacy and Computer Science courses for secondary education. Although the Netherlands currently does not teach any courses containing CT in primary or lower-secondary school education as part of the core curriculum, it is stated that some schools have been using their autonomy to teach programming classes even at primary level. At the moment the influx of new skill sets and tools for primary school computer education indicates the importance of continuing research into this growing type of education, and the emergence of autonomous programming classes even in primary school reinforces this need.

2.2 Children with visual disabilities

The JRC report[16] states that an inclusive approach should be maintained when implementing CT. A group that would benefit from such an approach are children with a visual disability. In the Netherlands there are two dedicated educational institutions for children with a visual disability that are specialized in their education, the Bartimus[2] and Visio[20]. There are 2,600 children in the Netherlands that fall under this group[9]. The term visual disability refers to the group of children that have a visual impairment, are blind or who have multiple (visual) impairments. The mentioned institutions offer dedicated schools for visually impaired children, but also offer assistance for children with a visual disability that attend regular public education, which the majority does. According to Visio[18] and Bartimus[1], approximately 80% of the children follow regular education while receiving outpatient educational support from Visio and Bartimus. The rest of the children follow special education at the schools from the institutions themselves.

Computer hardware like laptops, phones and tablets, and the skills related to them, are of particular

interest to the group of visually impaired students. For them these function as virtual prosthetics aiding them in their written communication and providing the tools to read, acquire and process any teaching materials[17]. Because of this, these students do not only follow regular computer education, but have a dedicated set of training courses to enable them to use these tools[19]. Within these courses they are taught to use Windows 10, many Microsoft Office programs, browsers and screen readers. A prerequisite for following these training courses is to be proficient in typing on a regular keyboard, for this there exists a special typing course[15].

2.3 Screen readers

To make use of laptops, phones and tablets people with visual disabilities make use of assistive technologies. A tool often used is the screen reader. A screen reader is an assistive technology tool used by children with a visual disability to be able to interpret digital content, it reads elements on the screen aloud and enables the user to navigate and select these elements. Benefits of using a screen reader are the speed and customizability of the tool, which are adjustable by the user. Research, mainly among blind adults, has identified some difficulties with the use of screen readers. In [5] Buzzi et al. studied the interaction of blind users with an open source Virtual Learning Environment and discussed how the W3C ARIA suite[21] could improve navigation of the virtual environment via screen reader. A problem found by this research is the use of images to provide information. The screen reader cannot interpret such elements for the user. Therefore they state it is important to make these accessible by providing alternative ways to display such information. A similar conclusion is made by Lazar et al.[10], which conducted research on the subject of screen readers and browsing the web. It describes one of the top causes of frustration in this context being the lack of alternative text for images. Another cause mentioned by both these researches is page layout. A screen reader can read all headers taken from the html of a webpage, this can give the user a global overview of what is on the page. Improper use of these headers can result in confusing feedback from the screen reader that does not properly convey the page layout, making navigation more difficult. Research into more general browsing with screen readers has also been conducted[4] and projects exist documenting the problems of accessing the web with the use of screen readers, taken on a yearly basis[22]. All of the studies mentioned focus on a wide age-range and their subjects mostly consist of adults. Most problems highlighted in these studies pertain to navigation difficulties while using screen readers, with the cause being the layout of code, order of displayed elements or lack of meta-tags.

Besides the aforementioned difficulties with screen readers, Buzzi et al. states that problems may be induced into the learning object itself, this is the lesson prepared by the teacher, if a virtual environment is designed without the proper knowledge of accessibility and usability issues in mind. In Lazar et al.[10], it is said that many of the more frequent causes of frustration with the use of screen readers are relatively easy to solve by developers. This is in line with the JRC Computational Thinking report[16], which highlights the need for an inclusive approach when introducing new virtual environments as stated before. If a programmer or publisher is not aware of the existing accessibility issues or how to implement such requirements, there is a high possibility that the experience for children with a visual disability using a screen reader will not be optimal, or more likely far from it.

With children using screen readers for educational purposes, many of these problems could realistically be found in educational software and websites, although it is not yet known to what extent these are experienced. As mentioned by[12], most of this content is not designed with children with visual disabilities in mind, many of which will make heavy use of visual elements and do not interface well with screen readers. It is also good to take into account that encountering such problems as described earlier will have a different impact on children than on adults. The reason for this is that these children have to learn the use of a screen reader next to any other courses they follow, as mentioned earlier. With this heightened workload, it could be more frustrating for children to experience the problems pertaining to accessibility. [12] describes that making this technology as easy to learn and use as possible will allow children to focus on the educational content.

3 Method

3.1 Participants

The participants chosen for the research were experts on the subject of assistive technologies in the context of the target group. An expert on this subject can be described as a person who works closely with the target group and has an important role within their organisation or school for the use and application of assistive technologies. The participants were part of two centres of expertise within the Netherlands on the subject of people with a visual disability, Visio and Bartimus. A total of four participants took part in the research, three male and one female. Their functions within the respective organisations were that of technology advisor, which naturally involved assistive technologies because of the nature of the organisations. One participant was active in a research and innovation team, with the focus on advising people with visual disabilities and multiple disabilities on the latest in technology that could help improve their day-to-day lives.

3.2 Measurements

To answer the research question, a qualitative research method was chosen, specifically interviews. Because of the lack of specific literature about the problem for the target group, the research focused on an exploratory approach. Because of this approach, a semi-structured interview method was used. These semi-structured interviews can lead to better understanding of the subjects perceptions and motivations and often yield a broader range of insights for the chosen themes, which can be used as entry points for further study[11]. An interview guide was used, which was constructed taking existing literature into account. It contained the following topics: field of work, visual impairments, school environment, assistive technologies, curriculum, computer use, screen readers, programming, teaching methods, and braille. Each of these topics contained main questions (e.g. Are screen readers used in the education?) and sub-questions (e.g. Which specific ones are used?). The sub-questions could be used to gather more specific information on a certain subject if relevant and to help guide the interview.

3.3 Procedure

The interview answered questions for two separate studies, which contained overlapping themes. Because of this, some questions were not relevant to the current research and thus not used. The participants were recruited using the snowball sampling method, starting with contacts from involved researchers. This method uses the participants themselves to find new participants and is useful for the current research because of the fact that the participants likely know other experts in their field of work. After this, appointments were made for the interviews, specifying the time and place of the interview. The interviews ranged from 30 to 45 minutes, two of which were conducted face-to-face at the workplace of the participant with both of the researchers from the involved studies. The other two were conducted via phone call, where only the author was present. An informed consent form was filled in prior to each interview by the participants to describe the nature of the research, to inform the participants about the handling of their data, and to get permission for recording the interviews. These recordings were made using two mobile devices when taken at the workplace, and two laptops when taken via phone call. The second recording was used as a backup measure, in practice they served well for inaudible speech. The recordings were uploaded onto university servers for safe storage and deleted from the original devices. Because of the exploratory nature of the research and given time constraints, four participants of the specified description were deemed sufficient for the performed analysis. Furthermore, the four participants combined were also representative for a large portion of the target group.

3.4 Analyses

The data analysis was conducted using a content analysis method, specifically thematic analysis. The interviews were first transcribed, verbatim style. The transcriptions were then open coded, data extracts that did not seem relevant at the time were also coded. Afterwards the codes were sorted by theme to find patterns within the codes. All data extracts where checked to see if they fit the overlapping theme. After identifying the themes, all of the data extracts contained within each theme were integrated into a narrative to arrive at an answer to the research question.

4 Results

In this chapter the results gathered from the thematic analysis are shown. First two background topics are introduced, after which the main findings are described.

4.1 Visual disabilities

On the first background topic of visual disabilities, the experts described the visual disabilities from their students as ranging from only having part of their vision, low vision, to being fully blind. Or similarly as one expert put it, Every kind of disability... within the spectrum of visual impairment. Here another expert notes that for them to follow education, the blind are in need of braille and those with low-vision need magnification or other aids to read the content to them.

Technology	Description	Specific Hardware/Software
Screen reader	Tool used for representing digital content with speech and braille.	JAWS, Supernova, NVDA, VoiceOver, Narrator.
Braille display	Displays the text from screen reader output in braille, using refreshable braille points to create braille characters.	No specifics mentioned.
Magnification software	Tool used to magnify digital content.	Magnifier, ZoomText, Fusion.

Table 1: Assistive technologies described in interviews

4.2 Used Technology

For the second background topic of technologies used, it appeared that the technologies mentioned by the experts were mostly the same for both institutions. This was the case for both the mainstream technologies (such as computers and laptops) as well as assistive technologies (such as screen readers). Information about the latter can be found in table 1.

Windows 10 is used on all computers and laptops that are used by the students in the schools, on which the assistive software tools are installed. The students themselves may choose which specific software tool(s) to use for a given assistive technology. This is because of the differences between those software tools and personal preference. Although third party assistive technology tools are used most often, one expert talked about Windows Magnifier and Narrator improving and the fact that there already exists a way to use a braille display through Windows. Besides the technology described in table 1, the experts also describe sometimes using braille printers, also known as braille embossers. One expert states that the reason for not using these printers often is the fact that there are many ways to get the same information, and that those alternative ways are more efficient (e.g. retrieving the information online).

4.3 Assistive Technology

The first theme directly connected to the research question concerns assistive technologies. When talking about the general state of technology used by their students, the first topic all of the experts mentioned was the difference in the technology used in relation to the past. Most talked about a big improvement in the accessibility of information for the students. One of the experts noted that, at the time of the arrival of Apple smartphones, tablets and other such technology, there was a rapid development in assistive technology. The expert specifically mentions the rise in popularity of speech synthesisers, a technology used in screen readers to voice text. The expert added that accessibility for their students was certainly improved during this time, mentioning that twenty years ago products were made specifically for their target group, and in contrast now many mainstream products have these accessibility features already built in. Another expert mentions a time when everything was done with braille, that this was the only way for blind students to gather and read information at the time. Both mention a time where, when requiring specific texts, a request from certain companies would be made, who would convert normal books into braille which would often

take weeks and sometimes months. The first expert added that compared to twenty years ago, the world of information is now much more open to their students. A third expert describes it as such:

You immediately have that information if something is digital, you don't have to wait very long for this information.

A second topic within the general state of technology concerns the use of said technology by the students. When tasked with switching to a new assistive technology, the students generally do not experience many difficulties. One expert states that this is a fairly quick process, which is mirrored by the statement of another expert:

If you are truly dependent on a certain assistive tool, then that adaptation is fairly easy.

The use of these assistive technologies is essential for the students, as said by one expert, because they have the cognitive ability to use these technologies to search for information and are learning how to read and write. Another expert shares this viewpoint, stating that the skills to use such technologies are very important for their type of education. Although this expert does comment that, when students think the technology they are learning will not help them, the adaptation will take much more time and effort. The distinction is made between a technology that a student depends on and one that could just be beneficial to the student. This largely depends on the type of visual impairment of the student, as a blind student would, for example, be more dependent on braille than a student with low vision.

Finally a third topic has been addressed by some of the experts. Although the focus of this study is on children with a visual disability, it is interesting to note a certain line of reasoning by two of the experts, as one states:

It is very good that you are looking at the children, but the teacher is also an important factor as it should also be user-friendly for them so they can properly support the children.

The expert states this as another reason for standardising the software and hardware of assistive technologies within his organisation. This is supplemented by the statement of another expert who says it costs a lot of energy for teachers to handle a screen reading program besides the subject they are already teaching. The expert states this as one of the biggest problems: the teacher not knowing what their students are capable of when using a screen reader. The expert continues, explaining that the most important thing for a teacher is to know what students are capable of when using the technology, instead of focussing on understanding the technology itself. It may not always be the ideal solution, one expert states, but for the teacher it is more convenient to only have one braille display or screen reader.

4.4 Screen readers

Coming to the core theme of the research, the technology that is found to be important by all of the experts are the screen readers. It is important to note that some students do not need the use of a screen reader, by making use of the accessibility settings on their devices they can change the way

elements are displayed on the screen. When this is done correctly, it can help a student with low vision to see enough elements of the screen to not be reliant on a screen reader to use the device. Here an expert specifically notes the Windows accessibility settings which can alter contrast, letter size and many other elements of the operating system to give users an easier viewing experience. Keeping this in mind, the fact remains that for most students with a visual disability the screen reader is an important tool, one which three experts state is essential to them. According to one expert, screen readers are the assistive technology with which the students begin, describing it as a must. This is echoed by another expert who states:

A computer without a screen reader is no longer a computer, because they cannot do anything with it.

The first difficulty the students encounter with the use of this technology is stated by one expert to be the shortcuts that are to be learnt to use a screen reader properly, which the expert states are numerous and thus make its use difficult. These shortcuts are used by the user of a screen reader to access specific menus, jump to specific places within a program and make use of many other functions that are normally accessed with the use of a mouse. A second difficulty mentioned by one of the experts concerns compatibility. As stated by one expert, when using a screen reader, you are dependent on the collaboration of two different pieces of software: the screen reader and the program you wish to use. This can often cause problems, sometimes resulting in the student not being able to use the program at all. Although it may seem that this would be the case for smaller, less popular programs, even popular software tools can have compatibility issues with screen readers. As mentioned by another expert for example, reading footnotes in Word with the use of a screen reader and braille display can be challenging and for some even impossible. This expert adds that when it comes to compatibility, there are naturally big problems.

4.5 Braille

A theme related to the use of screen readers is the use of braille, since a braille display can be used in conjunction with a screen reader. When using a screen reader, a braille display can be used to get braille feedback for certain pieces of text. These braille displays are mostly used by students who are blind. Within the context of purchasing the braille displays, two experts say there is not much choice in the Netherlands. One of them also states they are all starting to look very similar to each other. When a braille display breaks, the expert describes that if you give that student a braille display from another brand, the student will know how to use it within no time, because of the layout being largely the same. Buying braille displays is said to be about standardization by one expert. Another mirrors this view, mentioning that they try to get the best deal, as they use braille displays that are neutral, meaning no special functions. This expert goes on to say:

They must simply do what the screen reader asks of them.

Another topic concerning braille is its importance in the context of education and future use. As mentioned earlier, an expert stated that accessibility was improved by the rapid development of assistive technology, in particular the use of screen readers. This expert also mentioned that the use of braille seemed to be decreasing in that time and states that many problems were experienced, however no specific difficulties were mentioned. Most of the experts stated that braille is still very

important and one expert mentioned that they are trying to give it more attention within the schools. Additionally, an example is given by an expert about a student who would use braille whenever the subject matter the student listened to with a screen reader was getting difficult to follow. This is echoed by another expert, who states that braille is very important to get a clearer picture of a word and its characterization, and goes on to say that the idea of tactile representation of text will always remain. This is also conveyed by a third expert who says that certain things must simply be viewed with braille, and added the following:

Although the world is becoming more and more visual and working with sound in the regular world is increasing, this is also the case for blind and low-vision people. This does not mean that written text is less important for the seeing world or braille for the blind world.

4.6 Education

Children start learning to work with computers and assistive technologies like screen readers, whereafter the students begin with a typing course. They learn how to browse their files and find programs such as Word and access their files through it. This process continues, until learning the use of e-mail and Excel. Web browsing is something that is taught last, because of this being a point of friction. As one expert mentions, the student is dependent on what other people create when browsing the web, and the accessibility of this content can differ greatly per website. Besides the courses mentioned the theoretical foundation is the same for the students as regular education, with all the same subjects. Learning to use assistive technologies besides these is essential, as one expert states that much of the teaching material is offered digitally and must also be processed via a computer.

This is where the experts state that most of the problems encountered when using screen readers lie. First of all, one expert states that to use certain functionalities of specific software, other software is often needed to make it accessible, which complicates matters for students. The expert states that besides the need to use additional software, educational software is one of the biggest problems they encounter regarding the difficulties that are experienced. Another expert describes this as the developers not thinking about these specific users, but rather from the point of view of the features the program should have. This expert also adds: The user-friendliness leaves many things to be desired.

4.7 Difficulties

The previously mentioned friction with web browsing is a good example of another difficulty experienced while using screen readers. Many courses make use of web-methods to provide additional content, where students need to sign into a certain website to access this content. One expert describes this process: ... and then you arrive at the website, and then uh, yeah most simply cannot continue at all. Because the website just isnt accessible. The underlying problem that makes this content inaccessible concerns navigation and perception. As a blind or low-vision user you can get lost within the code of a web page very quickly, as one expert states you must be very proficient to navigate the internet successfully. Another expert describes an example of an educational website where images were used to convey most of the information, these images did not contain any

proper tags or descriptions, therefore no information could be gathered with the use of a screen reader. A third expert also mentions the use of web-methods that are totally inaccessible for screen readers. The expert states that although accessibility of websites does improve because of laws and regulations, the development of websites is going forward with incredible speed. This causes web-methods to be used that make these websites more advanced, yet at the same time less accessible. One expert mentioned an interesting view on the use of mobile devices for accessing web content, stating that it was easier to browse the content on these devices and that it felt more accessible.

One expert states that it was a struggle to get everything accessible twenty years ago, and that this is still a struggle today. The expert describes this with a Dutch proverb:

Dweilen met de kraan open [Filling a bucket full of holes]

With this proverb the expert conveys an unending process. The expert does add that these are not the same accessibility problems as twenty years ago that need fixing, providing the example that any normal text is already accessible nowadays. The expert states that because of this, the teaching method is changing, which in turn brings new accessibility challenges. Another expert complements this view with an example about an educational software kit that was found to be totally inaccessible for their students. The software kit was being used more and more in regular education. The expert states that, publishers in particular are not proficient enough at making content accessible. This thought is shared by all four experts. One expert states that the publishers do not find it interesting enough because it is such a small group. This expert says this is especially true for smaller companies. The developers within these companies however are thought to be proficient enough to implement the changes necessary for accessibility. This is where another expert states: ... awareness is step one I think. This lack of awareness is echoed by a third expert, who states that the biggest underlying problem is the lack of knowledge, and motivation for, accessibility. The expert states that this lack of awareness can result in a program that is 99% accessible by their students, while it can also result in a teaching method that is totally inaccessible. This expert adds:

So it can differ greatly what that conflict is, and what impact it has on how it works.

Another subject that is addressed by all of the experts concerns regulations and laws for accessible content. There is a general consensus that large companies do feel the pressure to make their content accessible. This is supported by the fact that some Dutch companies and institutions do contact the experts and their colleagues to see if their new content fits the needs of the visually impaired, although the content being accessible is mostly not the case. One expert puts their role this way:

We are like the knights in shining accessibility armor

5 Discussion

To reiterate, this research has conducted semi-structured interviews with experts in the use of assistive technologies by children with a visual disability to get answers to the following research question:

Which difficulties are faced with screen readers used in primary school computer and typing education by children with visual disabilities?

From the interviews with the experts it has been found that learning to use assistive technologies in primary school education is seen as a very important step for children with a visual disability. Many students are said to begin their digital education by learning the use of a screen reader, which is stated to be one of the more important assistive technologies for the target group by all of the interviewed experts. This gives a strong indication of the importance of researching the difficulties experienced by the target group in their use of screen readers. The process of learning an assistive technology was found to be fairly easy and quick, because of the dependency of many students on this technology to access digital content. Two experts stated that whenever a student is less dependent on, and does not see the benefits of, the use of an assistive technology, this adaptation could take more effort and time.

The first set of difficulties directly related to the research question focus on the use of extra software besides screen readers and the use of shortcuts. This first difficulty was however not mentioned by any of the other experts. This could be the result of these experts not thinking of the use of this extra software as a difficulty or problem, but rather as a solution to a difficulty. Another expert mentions the difficulty of using shortcuts, a certain combination of inputs on a keyboard, to navigate and interact with their device and its software. The expert states that this could be difficult because of the large number of existing shortcuts. This seems like a valid concern, as was shown earlier, Milne[12] states It is important to make this extra layer as easy to use and easy to learn as possible, so they can focus on learning educational content. Keeping track of the many shortcuts needed to effectively use the screen reader could have an impact on the focus and maybe even the performance of the child using the screen reader.

The second set of difficulties found pertain to educational web content, three experts mention different difficulties that are encountered while browsing this content using screen readers. First is the difficulty of navigation, where it is described that getting lost or even hitting a dead end in the code is something that occurs. This is in line with previous work researching web browsing with screen readers, such as Lazar et al.[10], which describes difficulties with navigation as one of the top causes of frustration. A second difficulty described by the experts is the lack of context for images used in educational web content, making this content inaccessible for children using screen readers. This is also mentioned in both Buzzi et al.[5] and Lazar et al.[10]. The inaccessibility of online educational content in web browsers can have the consequence for children using screen readers that certain educational content cannot be accessed. This is not ideal, as attending regular education could become more difficult because of this.

In accordance to previous work[10], the experts mention that most of the difficulties with web content could be solved relatively easy by the developers. With this we arrive at the third and most discussed reason by all of the experts for the difficulties faced with screen readers by children with a visual disability, namely that of awareness. All the expert provide examples of educational content made by publishers being inaccessible, stating that the publishers themselves are not proficient in making this content accessible. Within this context it is stated that the reason behind this

is either a lack of interest in the target group or a lack of awareness, the second being thought as the main reason. This lack of awareness could be the result of an overall absence of regulation pertaining to the making of accessible content, although this could also signify a scarcity of accessibility guidelines in development culture. As stated by the experts, larger companies do have an awareness of the fact that their content should be accessible to the target group, as noted by their willingness to approach the experts and their organisations for advice. This may be because of their larger presence drawing the eye of regulatory authorities, yet the greater existence of minority groups within their pool of customers in contrast to smaller companies may also play a role.

An interesting result found was the statement of two of the experts that the assistive tool should also be user-friendly for use by the teacher. Their argument being that the teacher could then properly support the children when they encountered any problems with the tool. This result is especially important when taking into account the fact that the majority of these children attend regular education, where most teachers would probably not be familiar with the use of assistive technology. Another concern mentioned by one of these experts was the fact that most teachers will not know what a student using a screen reader is capable of. This could have consequences for the accessibility of provided materials and exercises made by the teacher. This reasoning draws parallels to the reasoning of Buzzi et al.[5] about virtual learning environments, which states: ... if the virtual environment layout is not appropriately designed with a thorough knowledge of accessibility and usability issues, it may induce problems that could be spread to the learning objects themselves.

Although not the main topic of the research, it is interesting to discuss the statement of three of the experts regarding the use of braille displays. Here it is conveyed that whenever a student using a screen reader experiences difficulties understanding a certain word or phrase, that student will turn to braille to get a better picture of the word. The occasional need for clearer representation of text in braille when working with screen readers could indicate that students will keep using braille displays together with screen readers for the foreseeable future.

5.1 Limitations

The sample size of participants for the semi-structured interviews was small, which is reflective of the small population of experts. The results were not very in depth because of the exploratory nature of the research and the use of semi-structured interviews.

5.2 Further research

Because of the exploratory nature and broad findings of the research, many different areas could be interesting for further research. One area of particular interest would be to research the existence, or lack, of accessibility guidelines within publishers and developers of educational content. Another field that could be researched more thoroughly is the use of mobile devices on accessibility of websites.

6 Conclusion

In this paper the difficulties faced with the use of screen readers in primary school computer and typing education by children with a visual disability were researched. Semi-structured interviews have been held with experts in the use of assistive technologies to gather insights into the problem for the target group. It was found that the screen readers themselves are never stated to be the cause of any difficulties, not directly, and learning to use them will come easily for most children who are dependent on this technology to access digital content. The first main finding encompasses the use of the tool, specifically the many shortcuts required in its use. These shortcuts may have an impact on the focus of children on other tasks that are performed while using it, which could impact their learning performance. Secondly, difficulties were found in the use of educational web content. Navigational difficulties and the absence of context for images made the content inaccessible, which could make attending regular education more difficult for children with a visual disability. Furthermore most teachers in regular education are not aware of the capabilities of these students, which could also cause difficulties. The third and most discussed difficulty pertained to the awareness of companies and developers of the target group. Many of the prior difficulties have been found to be easily repairable to an accessible state. This awareness is found to be the underlying reason for the occurrence of many accessibility problems for screen readers.

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Appendix A

Leiden, maart 2019

Betreft: informatie en toestemming interview ‘Assistive technologies in het computeronderwijs voor kinderen met een visuele beperking’

Beste leerkracht,

U heeft aangegeven interesse te hebben om mee te doen aan een interview over assistive technologies in het computeronderwijs aan kinderen die slechtziend of blind zijn. Graag informeren wij u met deze brief verder over het onderzoek en wat u kunt verwachten.

Achtergrond en doel

Het interview maakt deel uit van een master project aan de TU Delft en een bachelor project aan de Universiteit Leiden. Met het interview willen we inzichten verkrijgen in het gebruik van assistive technologies door kinderen met een visuele beperking in het computeronderwijs. Hierbij zijn we vooral geïnteresseerd in punten waar u tegenaan loopt bij het gebruik van deze technologieën, vanuit de ervaringen van u en de kinderen in dit onderwijs. Met dit onderzoek streven we ernaar een goed beeld te krijgen van verschillende assistive technologies die gebruikt worden in het onderwijs en de issues die daarbij een rol spelen.

Opzet van het interview

De bijeenkomst bestaat uit een interview van 30 minuten. Tijdens het interview gaan u en de uitvoerende onderzoekers (Benjamin Bosdijk en Krishna Thiruvengadam Rajagopal) in gesprek over het computeronderwijs en de assistive technologies die hierbij gebruikt worden met betrekking tot kinderen met een visuele beperking.

Geluidsopname en dataverwerking

Om informatie uit het interview goed te kunnen verwerken, zal er tijdens het interview een geluidsopname worden gemaakt. De geluidsopname wordt alleen door de onderzoekers beluisterd en deze zal tevens (digitaal) in tekst omgezet worden. De informatie uit de opname wordt vertrouwelijk verwerkt. Dit betekent dat uw naam en persoonlijke gegevens losgekoppeld worden van de onderzoeksgegevens. Alleen de onderzoekers hebben toegang tot de opname, deze zal in een met wachtwoord beveiligde omgeving opgeslagen worden.

Toestemming

Wij willen u vragen het bijgevoegde toestemmingsformulier te tekenen. Met dit formulier geeft u toestemming voor uw deelname aan het interview en voor de geluidsopname.

Uw deelname aan het interview is vrijwillig. U kunt op elk moment voor of tijdens het onderzoek besluiten om niet meer mee te doen, zonder dat het nodig is te zeggen waarom.

Meer informatie

Als u nog vragen of opmerkingen hebt, kunt u contact opnemen met de uitvoerende onderzoekers, Benjamin Bosdijk (b.c.p.p.bosdijk@umail.leidenuniv.nl) en Krishna Thiruvengadam Rajagopal (K.T.Rajagopal@student.tudelft.nl), of met Anna van der Meulen (a.n.van.der.meulen@liacs.leidenuniv.nl , 071-5277054), begeleider vanuit Universiteit Leiden.

Met vriendelijke groet

Benjamin Bosdijk, Universiteit Leiden
Krishna Thiruvengadam Rajagopal, TU Delft
Anna van der Meulen, Universiteit Leiden

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TOESTEMMINGSFORMULIER

Ik verklaar hierbij dat ik geheel vrijwillig instem met mijn deelname aan dit onderzoek. Ik behoud daarbij het recht deze instemming weer in te trekken zonder dat ik daarvoor een reden hoef op te geven.
Ik verklaar ook dat ik toestemming geef voor de geluidsopname van het onderzoek.

Naam leerkracht: .....
Naam school: .....
Datum en plaats: .....
Handtekening:

Appendix B

Interview guide (combined)

Preface
- Introductions interviewer(s) and expert
- Have the informed consent form studied and signed
- Prepare sound recording (when permission is granted)
- Start the interview

General
We will start with some general questions about your position at the organisation and about the education of children with visual impairments in general.

- What is your function at your organisation?
- What kinds of visual impairments do the children at your school have?
- How are things in their environment generally adjusted to their situation?
- Is it difficult for children to switch from supporting technology?
- How do other disabilities that children have influence the use of computers and learning?

Curriculum
- What kind of computer education is given?
    - E.g. typing lesson, computer skills, programming lesson
- Do all students follow the same kind of computer lessons?
    - Are different classes offered on the basis of the type of visual impairment and / or other impairments?
    - How is the difference between children who are blind or visually impaired dealt with?
- Which computers / other hardware are used for this?
- Do all students use the same type of hardware?
- What types of software are used in education?
- Is programming learnt?
- Which language is learned first?

Computer use
Now we want to elaborate further on the use of assistive technologies in computer education. We are mainly interested in screen readers.

- Are screen readers used in education?
    - Which ones do you use?
    - Are there several or one?
    - Why was this chosen?
- Are there difficulties in using this?

    - Hardware (sound, compatibility software)
    - How does this influence teaching with this assistive technology?
- In your experience, what do the students think about the use of these screen readers?
    - What is it like for them when there are difficulties in using it?
    - Does this, for example, affect their motivation for computer lessons in general?
- How do the children navigate through the screen?
    - What strategies do they use?
    - What's going well?
    - Difficulties / What is going less well?
    - Is this different depending on the specific visual impairment that a child has?
- What is the most important issue when using screen readers when you look at your own and the children's experience?
- In the case of programming, how well does navigation go?
- Is braille hardware used?
    - If yes, which hardware?
    - Why was this chosen?
    - What is your experience with this?
- When purchasing assistive technology, what is this taken into account?
    - What considerations play a role? E.g. standards, costs.

Learn methods

Finally, we have a few background questions about teaching children with a visual impairment.

- What were the traditional methods of learning to read and write before computers began to play a more important role?
    - With / without braille
- What do you think about the future of Braille?
    - Is this becoming less important / outdated?
    - Why?

Conclusion

- Stop recording
- Other questions
- Thank and close interview