Review

Computer-based Assistive Technologies in Education for Students with Disabilities

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Summary

The aim of this paper is to accentuate the role of computer-based assistive technologies in the education process of students with disabilities. The paper presents preferred assistive technologies and types of educational problems that disabled students face. Impact of assistive technologies on independence in education and on quality of studying was also analyzed. Since the focus of this paper lies on the usability of computer-based assistive technologies, as fundamental elements of the education of disabled students, the importance of their accessibility is being particularly emphasized.

Key words: computer-based assistive technology, education, students with disabilities, speech technology, communication, input technology, Barthel index

Introduction

Today, people use technology to function more completely and efficiently in their lives. However, for people with physical disabilities, it is very often impossible to function in a world designed for people without disabilities, so they take advantage of a variety of methods to gain access to information technology and computer-based assistive technologies for (wireless) communication, mobility and daily living tasks. According to Raskind (2000), assistive technology can be defined as any item, piece of equipment or system that helps people bypass, work around or compensate for learning difficulties, which cannot be cured or outgrown. Learning disabilities are professionally diagnosed learning difficulties with reading, writing, speaking, listening, spelling, reasoning or math that are the result of a presumed central nervous system dysfunction. Nowadays, the computers are needful instruments for students with disabilities,

offering them a new perspective and a new way to live and learn. Many people with severe physical disability but normal speech (e.g. spinal injuries) use speech recognition as a mean to input text, as it can give faster input rates than adapted keyboards (Hawley et al., 2005). Because disabilities differ among students, each student must be fitted with assistive technologies that are commensurate with their individual needs (Christmann and Christmann, 2003). For such users, the products which have existed on the market offer additional accessibility to computers and are created for each type of disability (Isaila and Smeureanu, 2008). For example, assistive technology for visually impaired students includes screen enlargers and text readers, speech recognition systems, text-to-speech synthesizer, assistive input technologies, such as optical character recognition (OCR), word prediction programs, etc. Assistive products for persons with mobility disabilities include speech technology systems, wireless communication technologies, editing programs on screen using alternative electronic products, alternative keyboards, keyboard filters for editing or touch screens. Students with learning impairments can use word prediction and reading comprehension programs or speech technologies.

Speech technologies

Speech technology is potentially of enormous benefit to students with unintelligible speech (or no speech) and therefore has an important role in support for spoken communication. In order to be successful, speech technologies should effectively take into account the needs of user groups and have the ability to adapt to the needs of individuals. Communication aids range from simple devices which play back a small number of messages stored as recorded speech, to very sophisticated devices allowing access to large annotated vocabularies with synthesized speech output (Hawley et al., 2005). Recent speech technology research for Croatian language has concentrated upon speech synthesis (Boras and Lazić, 2006) and particularly on domain-specific evaluation of synthesized speech in order to increase the naturalness of artificial speech (Dunđer et al., 2013).

Text-to-speech synthesis

Text-to-speech systems have a vast range of applications. First real use was in reading systems for visually impaired people, where a system would read some text and convert it into robotic-sounding speech. Today, sophisticated systems can help impaired users to navigate around a computer system (Taylor, 2009). Text-to-speech synthesis can also be applied in an automated dialogue system, which then allows users to conduct entire financial or similar transactions. Reading systems for reading news stories, weather reports and travel directions are also based on this technology. They convert text that is displayed on the computer monitor into speech, allowing students to gain independent access to assignments, books, and learning material. Teachers or students do, however,

need to pre-scan material before they can use it (Wade-Woolley, 2005). Such systems have also shown to be useful to individuals with cognitive disorders and communicative impairments, especially for practicing writing and reading (MacArthur et al., 2001). In addition, research has shown that the use of this technology can actually improve word-recognition and decoding skills (Torgesen and Barker, 1995). Specific synthesis tools, e.g. screen readers are used to transform a graphic user interface (GUI) into an audio interface by verbalizing and converting every object on the computer screen including text, graphics, control buttons and menus into a synthetic voice that is spoken aloud.

Speech recognition

Speech recognition is a complex process, in which a sound is converted into electric signal, processed and then transformed into text. It can help physically disabled students to control a computer via voice trough a microphone or to input text. It is also useful for quickly writing down ideas (De La Paz, 1999), for practicing writing, spelling, reading comprehension and word-recognition (Higgins and Raskind, 2000). The speed of speech recognition also gives it a potential advantage over other input methods commonly employed by physically disabled students. But, it is also the case that many students prefer the non-speech alternative as they find speech recognition frustrating, due to less than perfect recognition or a nonintuitive way of composing text (Hawley et al., 2005). Speech recognition software works with most word processing systems, but a user has to train the computer to recognize voice patterns and pronunciations by reading specific text. The more a user uses a speech recognition system, the better it gets, eventually reaching sufficient accuracy. It can be particularly helpful to individuals whose oral language skills exceed their written production. Although, speech recognition is most useful for students who are verbally fluent, with daily and supervised use it can also have a positive influence on the performance of less verbally fluent students (Wetzel, 1996).

Wireless communication technologies

Use of computers for communication and networking activities via the internet can expand the learning environment beyond the walls of the classroom and allows students with disabilities, just like other students, to conveniently access and send information anytime and anywhere, without constraints of time or place (Hasselbring and Williams Glaser, 2000). Communication technologies become a valuable tool for learning if they offer disabled students opportunities to gather a wide variety of resources and information. Networked through the internet, such a collaborative learning environment enables students to practice communication skills without fear of being stigmatized because of their disability and to exchange ideas, information and knowledge with others. Mobile devices can complement and add value to the existing learning models (Motiwalla, 2007). However, mobile technology is limited by screen size, computa-

tional power, battery capacity, input interface and network bandwidth (El-Hussein and Cronjé, 2010). Nevertheless, e.g. Bluetooth enables wireless data transmission and offers a connection with two or more devices over a short distance. This makes it ideal for a portable and free of charge learning environment, which allows students to actively participate in the class and answer instructor's questions in an easier way.

Assistive input technologies

Assistive input technologies are designed to provide additional computer accessibility to individuals who have physical or cognitive difficulties, impairments or disabilities and allow individuals to control their computers through means other than a standard keyboard or a pointing device, using alternative (on-screen) keyboards, special pointing devices, sip-and-puff switches, wands and sticks, joysticks, trackballs, touch screens, eye or head movement and eye gaze systems, light-sensitive or pressure-sensitive systems, speech/voice-activated systems, word prediction tools etc. (Obiozor, 2010).

Optical character recognition (OCR)

Optical character recognition (OCR) systems, when combined with speech synthesis, might be used as reading machines. The OCR enables users to input hard copy text directly into a computer. Then the speech synthesizer reads the text back out loud. In this way, user can hear as well as see the text (Raskind, 2000). OCR combined with speech synthesis can be particularly helpful to students who have relatively few problems comprehending spoken language, but have great difficulty with decoding of text (Montali and Lewandowski, 1996). The OCR works with a scanner or similar devices, e.g. reading pens, which are primarily designed to read aloud single words, rather than full sentences (Higgins and Raskind, 2005). The scanner reads printed material, converts it to a computer file and then shows it on a computer screen. OCR software recognizes text by analyzing the structure of the object that needs to be digitized, by dividing it into structural elements and by distinguishing characters through comparison with a set of pattern images stored in a database and built-in dictionaries. This allows conversion of scanned input text from bitmap format to encoded text. However, errors are unavoidable in optical character recognition, and the noise induced by these errors presents a serious challenge to later-stage usage of data (Seljan et al., 2013). OCR systems are available as self-contained units or as systems which work together with computers.

Touch screen technology

Touch-sensitive screens are popular with young computer users and with individuals who have severe developmental or physical disabilities (Hasselbring and Williams Glaser, 2000). This technology allows users to simply touch the computer screen to perform a variety of tasks.

Word prediction

Word prediction programs work together with word processors. These programs predict the word a person wants to enter into the computer (Mirenda and Turoldo, 2006). The person types the first letter of a word, and the program, e.g. T-9 (Text on 9 keys) predictive text technology offers a list of words beginning with that letter. If the desired word appears, it can be chosen from the list by pressing the number on the keyboard that is displayed next to that word or by pointing and clicking with the mouse. That word will automatically insert into the sentence. If the desired word does not appear on the list, the user continues to type the next letter until it does appear. After the user chooses a word, the computer predicts the next word in the sentence. Again, it offers a list of possible words, even before the first letter is typed. Predictions are based upon the sentence content and spelling, as well as the number of times a word is used (Raskind, 2000). Word prediction may be helpful to individuals who have problems with keyboarding, spelling or grammar. These programs may also assist people who struggle to come up with the exact word they want to use in a sentence (Tumlin and Wolff Heller, 2004).

Research and methods

The main hypothesis of this paper is that students with disabilities at the University of Zagreb use computer-based assistive technologies for educational purposes on a daily basis. The idea of this research was to obtain a general overview of the students' satisfaction with assistive technologies, but also to identify characteristics and problems in the process of education of this target group. The research was carried out among undergraduate, graduate and postgraduate students with disabilities at the University of Zagreb. Conducting an online survey was chosen as the research method. The survey method comprises completing an anonymous online questionnaire with 23 open-ended and closed-ended questions. The research was performed in June 2013 on a sample of 10 students; therefore this research is based on ten complete questionnaires. Representativeness of the research sample might not be ensured due to low sample size, but still, representativeness of a sample is not guaranteed by its size. Furthermore, there are is no official and up-to-date data on the number and profiles of students with disabilities at the University of Zagreb. The questionnaires were analyzed quantitatively and qualitatively via content analysis, in order to decipher key problems mentioned among the participants. They were asked to undertake a questionnaire concerning how they consume and perceive computer-based assistive technologies for educational purposes and especially focusing on earlier experience, usability of computer-based assistive technologies, and what technology they find most useful regarding their type of disability. Respondents were also asked to describe their type of disability using Barthel index, which assesses self-care, mobility and continence. Barthel index allows the standardization of treatment and follow-up records, and these scores have

been reported to have a direct relation with the degree of independence of a patient (Wolfe et al., 1991).
In this research authors used a modified Barthel index scale ranging from:

- severe disability - constant nursing care, attention, bedridden, incontinent,
- moderately severe disability - unable to attend to own bodily needs without assistance, and unable to walk unassisted,
- moderate disability - requires some help, but able to walk unassisted,
- slight disability - able to look after own affairs without assistance, but unable to carry out all previous activities,
- no significant disability - able to carry out all usual activities, despite some symptoms.

Results and discussion

Table 1 shows research statistics and first results of the conducted online survey. Most respondents were male (90%) and were coming from different fields of study - Economics, History and Rehabilitation science were mostly represented. Average age was cca. 29 years and 50% of them were still undergraduate students. Among the respondents were also three postgraduate students. 70% of all respondents had moderately severe disability, 2 respondents had slight disability and only 1 no significant disability. All of the respondents had prior experience with computer-based assistive technology, while most of them use free technologies (40%) on a daily basis. 30% uses a combination of free and commercial tools, while one respondent uses only traditional non-electronic technologies. Why this respondent uses only traditional technologies is unclear, but this opens a new question about accessibility of computer-based assistive technologies for disabled students in the education process (price, effort, usability problems, additional training).
Chart 1 shows that even 70% of all respondents had prior experience with speech technologies, mostly using text-to-speech systems in form of screen readers, and speech recognition. Half of respondents had also prior experience with wireless communication technologies, e.g. Bluetooth, which they mostly used for transferring data, homework assignments, for sharing and retrieving study-related information and for taking notes virtually on different electronic devices. 50% of the respondents have also experienced working with assistive input technologies, mostly OCR for digitizing learning material, on-screen keyboards, but also word prediction tools for speeding up text input.

Table 1: Research statistics and results

Respondents	**male**	**9**	
	female	1	
	total	**10**	
Average age of respondents		28,6 years	
Education level		Undergraduate	**5**
		Graduate	2
		Postgraduate	3
Field of study		Economics	**2**
		History	**2**
		Rehabilitation science	**2**
		Accounting and audit	1
		Information and communication sciences	1
		Public administration and public finances	1
		Sociology	1
Barthel index		severe disability	0
		moderately severe disability	**7**
		moderate disability	0
		slight disability	2
		no significant disability	1
Prior experience with computer-based assistive technology		yes	**10**
		no	0
Type of computer-based assistive technology you use		free	**4**
		free and commercial	3
		commercial	2
		none (using traditional technologies)	1

Source: Research conducted in June 2013.

Chart 1: Prior experience with specific computer-based assistive technologies

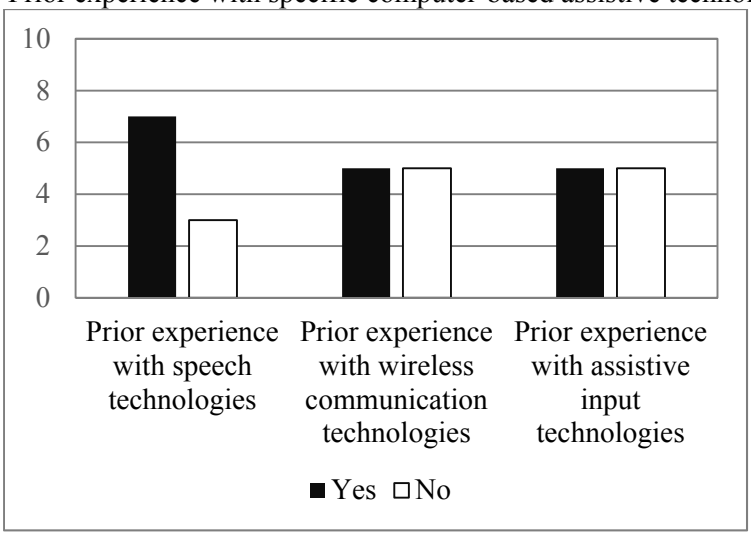
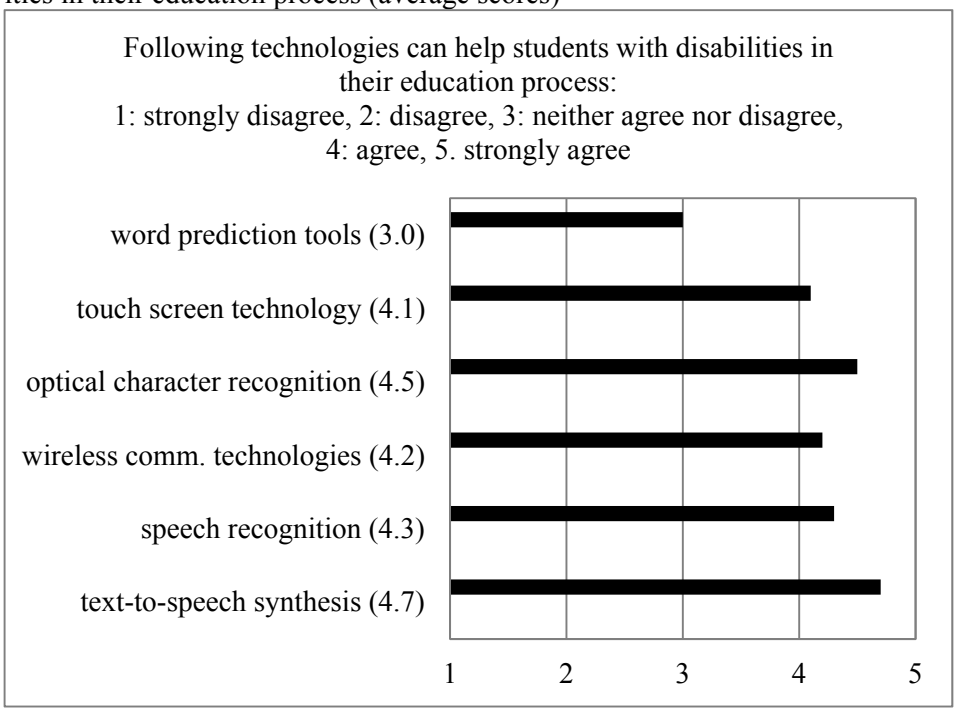


Chart 2 shows how students with disabilities at the University of Zagreb perceive different types of computer-based assistive technologies. The chart is based on Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree) and shows that text-to-speech synthesis (4.7) and optical character recognition (4.5) scored best. In other words, according to our target group those two technologies have more educational advantages than other mentioned technologies. Word prediction tools scored worst (3.0), indicating that students neither agree nor disagree with the claim that word prediction tools can help in the education process.

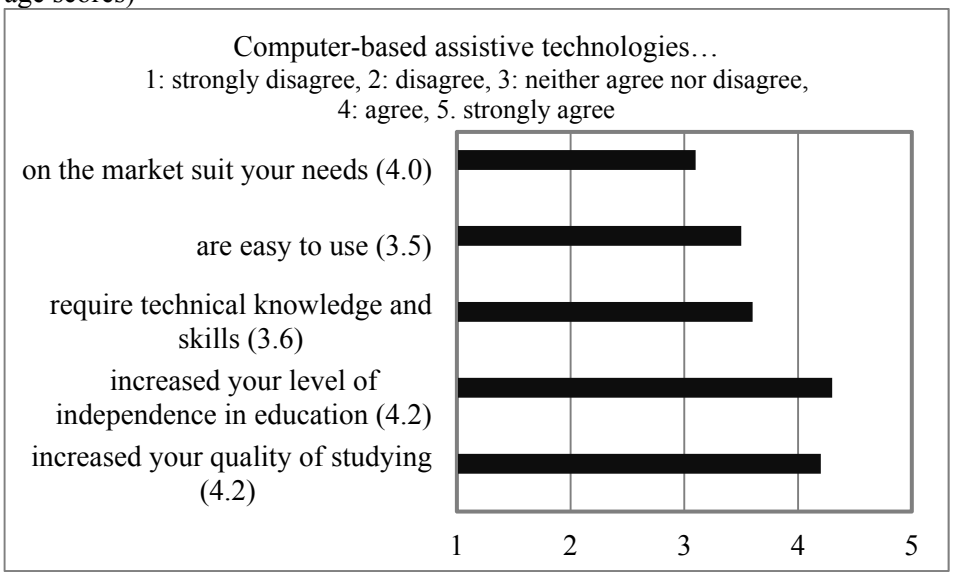
Chart 2: Useful computer-based assistive technologies for students with disabilities in their education process (average scores)



Furthermore, respondents were mostly satisfied with the assistive technologies on the market and their usability, but pointed out that for the effective use, technical knowledge and specific skills are needed, as shown in chart 3. They also claimed having increased their level of independence in education (4.2) and quality of studying (4.2) by using computer-based assistive technologies.
Eventually, respondents were asked to name a computer-based assistive technology that they found the most useful during their education process. 60% answered optical character recognition (3 respondents) and wireless communication technologies (3 respondents), followed by speech technologies (40%) –

text-to-speech synthesis (2 respondents) and speech recognition (2 respondents). Touch screen and word prediction technologies were not mentioned.

Chart 3: Computer-based assistive technologies currently on the market (average scores)



Conclusion

Assistive technology is a type of technology that is available for people with disabilities. Basically, anything that makes a task easier to perform is considered assistive technology, while computer-based assistive technologies are supported by a computer, or a similar electronic device. In this paper, a research in form of an online survey was conducted on a sample of ten students with disabilities at the University of Zagreb. Seven students out of ten had moderately severe disability according to Barthel index. The research gave valuable information on type of assistive technologies used by students in order to enable and enhance education. Furthermore, it was shown that all respondents had prior experiences with computer-based assistive technologies and 90% of them used those technologies on a daily basis. Therefore, the main hypothesis was confirmed. The authors showed relevant information on type of preferred assistive technologies in education: speech technologies and OCR, followed by wireless communication and touch screen technologies. Also most of the respondents favored non-commercial technologies and stated that computer-based technologies increased their level of independence in education and quality of studying. This underlines the huge importance of accessibility of computer-based assistive technologies for disabled students in their education process. Generally, a very positive attitude towards assistive technologies was

noticed, i.e. most of the scores were between 4 (agree) and 5 (strongly agree). Further research on a larger target group is planned in order to uncover real problems in the usage of existing computer-based assistive technologies and to identify space for improvements or modifications.

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