Evaluation of Mainstream Tablet Devices for Symbol Based AAC Communication

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Abstract. Rapid evolution of mobile devices enables the today's user to access the content and technology previously reserved for multiple devices in one compact, portable package. The introduction and popularization of smartphones, tablets and e-readers changed the way that the users communicate, consume and create content. This paper examines the potential of using such devices for symbol-based Augmentative and Alternative Communication. We have proposed a model of an adaptive symbol-based AAC application for mainstream mobile devices. In respect of the requirements of the model we have examined technical possibilities and limitations of specialized and mainstream tablet devices available. Via a preliminary research of potential symbol-based AAC users in Croatia we have investigated the current state, needs and requirements regarding the use of digital AAC applications.

Keywords: Augmentative and Alternative Communication, Mobile devices, Tablets, Symbols.

1 Introduction

Mobile devices have become an important part of our daily lives. Having started as devices that created freedom in voice communication, they have developed into powerful multimedia platforms. According to the latest reports, smartphone penetration in the U.S. market was 44% of all mobile phone devices in 2011 [1].

In times when a large part of social interaction is happening online, whether via e-mail, online forum and chat systems or social network websites, users with special needs are often excluded because of technological and functional limits imposed by the dedicated solutions they use. This digital exclusion is preventing individuals with disabilities from having socially active and independent lifestyle [2]. AAC users think that the technology and AAC solutions "must support full participation in all aspects of 21st century life" [3]. In the year 2005 the European Union started a "i2010" initiative, which promotes "e-Accessibility" with the goal of enabling access to ICT applications, services and devices to people with disabilities [4].

The most important part of the HCI process using symbol based AAC programs and services on touch screen mobile devices is happening on the very screen – from symbol display and browsing, to the selection process and word construction. It is therefore essential that the design and display of symbols and user interface lend themselves to screen specifications. A number of portable devices with touch screen interface and mobile operating system – from mobile phones and tablets, to e-readers

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and digital cameras, many of them using different display technologies and sizes, is growing constantly. Even in the same category of devices, the manufacturers are using different screen sizes and display technologies to diversify their product lines or to cut costs. Unlike the dedicated AAC solutions, where the manufacturer has full control over device specifications and software implementation, AAC programs and services for mainstream mobile devices should demonstrate functionality on a wide range of display types, sizes, resolutions, colour spaces and refresh rates. Due to such a variety, there is a need for a different approach to design and the development of symbol-based AAC programs and services for these devices.

2 Model of Adaptable Symbol Based AAC Application for Mainstream Mobile Devices

The proposed model is an adaptive system that will adjust the display of symbols and user interface to the specifications of the device, but also to the capabilities and preferences of the users (Fig. 1).

The system will use specially developed symbols which will enable the change in size without significant loss in quality. Each symbol will have three different visual variations – one using full 16 million colour palette, the other using limited colour palette and a black-and-white variation. Each variation will be able to feature animation of graphic objects. The user would be able to use symbols from an online repository or store them for local use.

Upon the first use of the system, the user or his assistant would set their preferences regarding symbol type, size, GUI layout and the use of colours and animation. The system would then upload the preferences to an online database.

After the installation on a new device, the program will automatically set minimum symbol size taking into consideration screen resolution, maximum number of displayed symbols based on the screen size and minimum symbol size, colour reproduction based on the screen colour space specifications and the possibility of animation regarding screen refresh rate and the processing power of the device. These settings will then be combined with user preferences to create the final display of the symbol-based AAC application on the device. User preferences may not exceed the boundaries that the program determined in respect of the specifications of the system.

When the application is used with another device, it will automatically optimize its display to suit the screen specifications and user preferences. This will enable the users with multiple mobile devices to use same AAC solution on every device without having to set it up manually every time they use it. Furthermore, the program will work on most upcoming devices with the same mobile OS, thus enabling AAC users to follow technological advancements easily.

Since such system largely depends on user preferences, requirements, possibilities and expectations regarding the use of such system with mainstream mobile devices, it is important to include the user in the design process using principles of User Centred Design (UCD). The importance of user feedback is often overlooked when designing such services, despite their requests to participate in such projects [3].

For this system to work, it is important that the specifications of mobile devices used meet some minimal requirements. Since they should offer a similar level of functionality compared to dedicated mobile devices, they should have a similar range of screen sizes, and similar or better hardware specifications. Also, since this is an adaptable system, it is important that the mobile operating system used works on several different devices and that it allows access to different hardware components. All this requires a more detailed insight into technical capabilities of dedicated and mainstream mobile devices.

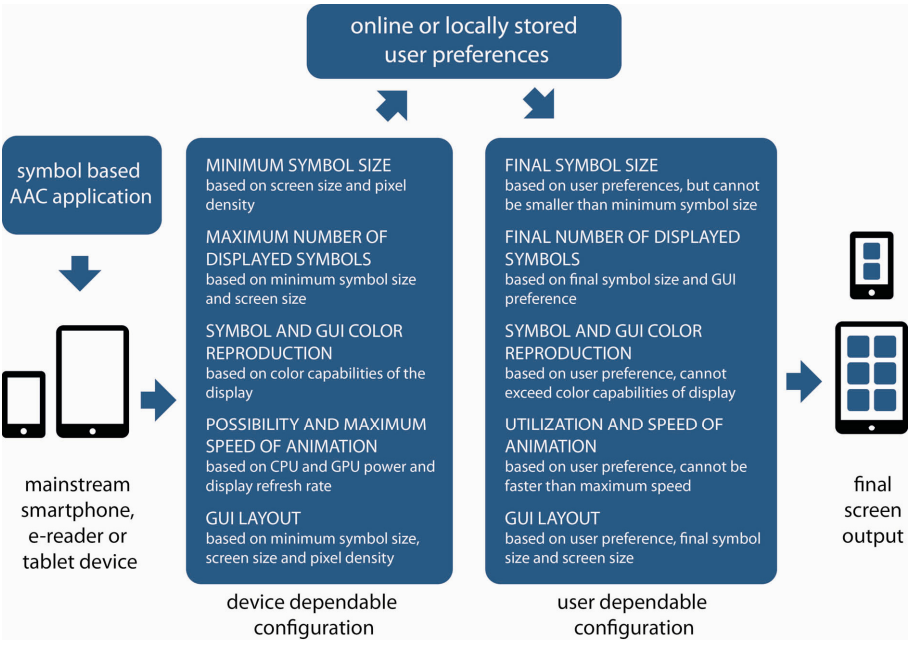

Fig. 1. Model of adaptive symbol based AAC application for mainstream mobile devices

3 Analysis of Dedicated AAC and Mainstream Mobile Devices

Users of symbol-based AAC systems can use dedicated and non-dedicated electronic devices to help them facilitate the communication [5]. While non-dedicated devices are mainstream technologies that use AAC software, dedicated devices are built specifically for this kind of user base.

In order to get a better insight into the capabilities of current dedicated AAC mobile devices, we have made an evaluation of their technical characteristics and compared them to mainstream tablet devices of similar screen sizes (Table 1, 2).

The evaluation of the device has been made for the U.S. market because it offers the widest range of dedicated AAC devices. The majority of evaluated mainstream devices are available worldwide, while dedicated AAC devices have limited availability and are distributed mainly on larger North American and European markets.

Table 1. Evaluation of dedicated AAC and mainstream tablet devices with screen sizes form 7 to 9 inches

	mainstream tablet devices			dedicated AAC tablet devices						
Device name	**Samsung Galaxy Tab 8.9**	**Barnes&Noble Nook Tablet**	**Samsung Galaxy Tab 7 Plus**	**Springboard Lite**	**Vantage Lite**	**Jabbla Mobi 2**	**Tobii C8 Communication aid**	**Jabbla Zingui**	**Words+ Sam Tablet SM1**	**Dynavox V+**
Screen type	LCD	IPS LCD	LCD	LCD	LCD	LCD	LCD	LCD	LCD	LCD
Screen size	8.9 in	7 in	7 in	7 in	8.7 in	8.4 in	8.4 in	8.4 in	8.4	8.4
Resolution	1280 x 800 px	1024 x 600 px	1024 x 600 px	800 x 480 px	800 x 600 px	800 x 600 px	800 x 600 px	640 x 480 px	800 x 600 px	800 x 600
Pixel density	170 ppi	170 ppi	170 ppi	133 ppi	115 ppi	119 ppi	119 ppi	91 ppi	119 ppi	119 ppi
CPU type and clock speed	dual-core, 1 GHz	T.I. OMAP 4 dual-core, 1 GHz	Exynos dual-core, 1.2 GHz	N/A	N/A	AMD Geode LX800, 500MHz	Intel Core Duo U2500	Marvell Xscale PXA	AMD Geode, 800MHz	Intel Atom, 1.6 GHz
RAM size	1 GB	1 GB	1 GB	N/A	N/A	1 GB	2 GB	128 MB	128 MB	1 GB
Memory size	16 GB (32 GB optional)	16 GB	32 GB	N/A	N/A	8 GB	60 GB	1 GB	2 GB	80 GB
Camera	Yes, 2	No	Yes, 2	No	No	No	Yes	No	No	No
Camera resolution	rear – 3 MP front – 2 MP	/	rear – 3 MP front – 2 MP	/	/	/	0.3 MP	/	/	/
Connectivity	Wi-Fi Bluetooth USB 2.0 microSD card head phone (3G/4G optional)	Wi-Fi USB 2.0 microSD card headphone	Wi-Fi Bluetooth IR control USB 2.0 microSD card head phone (3G/4G optional)	IR control USB SD card microphone head phone switch (Bluetooth optional)	Bluetooth IR control USB SD card speakers head phone switch	Wi-Fi IR control USB switch (Bluetooth optional)	USB SD card LAN switch port head phone (Wi-Fi, Bluetooth optional)	USB switch (IR control optional)	USB switch	Wi-Fi Bluetooth IR control USB switch head phone microphone
GPS	Yes	No	Yes	No	No	No	No	No	No	No
Integrated Speakers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Integrated Microphone	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes
Battery life	9 h	9 – 11.5 h	8 h	6 - 8 h	5 – 7 h	N/A	6 h	N/A	4 – 6 h	9.5 h
Operating system	Android OS, v3.1	Android OS	Android OS, v3.2	Unity Language System	Unity Language System	Windows XP home	Windows 7	Windows CE	Windows CE	Windows 7
Device dimensions (WxHxD)	231 x 157 x 8 mm	205 x 127 x 12 mm	194 x 122 x 10 mm	185 x 185 x 45 mm	220 x 234 x 41 mm	327 x 245 x 40 mm	239 x 201 x 38 mm	215 x 165 x 38 mm	267 x 220 x 51 mm	230 x 200 x 70 mm
Device weight	448 g	400 g	343 g	1133 g	1530 g	1750 g	1800 g	1080 g	1769 g	2040 g
Price	$ 400	$ 250	$ 449	$ 2595	$ 7495	$ 7795	$ 6395	$ 4095	$ 7095	$7800

3.1 Dedicated Mobile Devices for Symbol Based AAC Use

With rapid advancement of mobile technology, dedicated AAC devices keep failing to follow the trends and technologies found in mainstream mobile devices. One of the main problems is that dedicated mobile AAC devices are not providing access to multiple communication functions and electronic tools, as opposed to mainstream tablets and smartphones [6]. They often lack usable hardware components like a camera to enable the users to create their own graphic signs by utilising photographs taken or GPS module, so they could find their way around if they are lost or send information about their current location. Also, since they often use customized operating systems and proprietary software, there are not any options for expanding the capability of the device by installing additional applications made by development community. This lack of convergence hinders user's ability of accessing and consuming media and can limit his communication and socialization ability.

The main interactive part of these devices, the touch sensitive display, is also not at the same level as the current mainstream offerings, often having limited colour reproduction and lower resolutions. Snellan 20/20 acuity for viewing distance of 50,8 cm requires screen pixel density of 172 ppi (pixels per inch) [7] but it is normal for children and young adults to have 20/16 acuity and they should therefore be able to

resolve details on screens with higher pixel density [8]. Some authors claim that, by varying grey levels of pixels making up the characters, pixel density as low as 140 ppi can be used to display text with performance equivalent to that of a printed page [9, 10]. Unfortunately, from the evaluation of dedicated AAC mobile devices (Table 1, 2) it can be seen that all devices use lower pixel densities, some even going as low as 91 ppi. These low pixel densities can limit user performance and cause discomfort [11].

Table 2. Evaluation of dedicated AAC and mainstream tablet devices with screen sizes form 9 to 12 inches

	mainstream tablet devices			dedicated AAC tablet devices		
Device name	**Apple iPad Wi-Fi +3G**	**Samsung Galaxy Tab 10.1 4G**	**ASUS Transformer Prime**	**Words+ Conversa**	**DynaVox Maestro**	**Tobii C12 AAC device**
Screen type	IPS LCD	LCD	Super IPS LCD	LCD	LCD	LCD
Screen size	9.7 in	10.1 in	10.1 in	12 in	10.4 in	12 in
Resolution	1024 x 768	1280 x 800	1280 x 800	N/A	1024 x 768	1024 x 768
Color range	132 ppi	149 ppi	149 ppi	N/A	123 ppi	107 ppi
CPU type and clock speed	Apple A5 dual-core, 1 GHz	Cortex A9 dual-core, 1 GHz	Cortex A9 quad-core, 1.3 GHz	Intel Core 2 Duo, 1.5 GHz	Intel Atom, 1.6 GHz	Intel Core Duo U2500
RAM size	512 MB	1 GB	1 GB	2 GB (4 GB optional)	1 GB	2 GB
Memory size	32 GB (64 GB optional)	32 GB (64 GB optional)	32 GB (64 GB optional)	120 GB	64 GB	60 GB
Camera	Yes, front and rear	Yes, front and rear	Yes, front and rear	No	No	Yes
Camera resolution	rear - 0.7 MP front - 0.3 MP	rear - 3 MP front - 2 MP	rear – 8 MP front – 1.2 MP	/	/	0.3 MP
Connectivity	Wi-Fi Bluetooth 3G head phone dock connector	Wi-Fi Bluetooth USB microSD card 3G/4G head phone port	Wi-Fi Bluetooth microSD card head phone microphone dock connector	Wi-Fi LAN Modem USB IEEE 1394a	Wi-Fi Bluetooth IR control USB head phone microphone switch	LAN USB SD card switch head phone (Wi-Fi, Bluetooth optional)
GPS	Yes	Yes	Yes	No	No	No
Integrated Speakers	Yes	Yes	Yes	Yes	Yes	Yes
Integrated Microphone	Yes	Yes	Yes	Yes	Yes	Yes
Battery life	9 – 10 h	9 h	12 h	3.5 h (7h with extended battery)	3 h (9.5h with extended battery)	5 h
Operating system	iOS	Android OS	Android OD, v3.2	Windows XP Home	Windows 7	Windows 7
Device dimensions (WxHxD)	241 x 186 x 9 mm	257 x 175 x 9 mm	263 x 181 x 8 mm	293 x 220 x 89 mm	270 x 216 x 47 mm	312 x 264 x 46 mm
Device weight	613 g	567 g	586 g	2041 g	1250 g	2900 g
Price	$ 729	$ 630	$ 500	$ 8295	$ 8025	$ 7395

Since manufacturers base their software implementation on the PC operating systems, which are less CPU and memory efficient and are not fully optimized for touch input, these devices are larger and significantly heavier than comparable mainstream devices, often having shorter autonomy time (Table 1, 2).

Despite a somewhat older technology, mobile AAC devices can be more than 15 times more expensive than mainstream tablet devices (Table 1, 2), which makes them less accessible to users in countries where they are not subsidized by medical institutions. Furthermore, the lack of support for multiple languages makes these devices unattractive to users outside the English speaking countries.

3.2 Mainstream Mobile Devices

While early mainstream mobile devices lacked touch screen input and had low resolution screens and limited colour reproduction, today they are sophisticated devices that, among other capabilities, are able to display detailed graphics on high resolution displays. With the advancement of technology and the introduction of mobile platforms utilizing dual-core and quad-core Central Processing Units (CPU) combined with powerful Graphical Processing Unit (GPU), the today's mainstream mobile devices are even capable of running complex 3D applications, filming and reproducing high definition video and doing tasks previously reserved for personal computers.

Whereas smartphones usually have smaller screens than the majority of symbol-based AAC devices, mainstream tablets have similar screen sizes as dedicated AAC devices (Table 1, 2), and therefore more potential to be used as a non-dedicated AAC device.

Unlike dedicated AAC devices, which use mainly customized PC operating systems, mainstream smartphone and tablet devices use operating systems developed and optimized for mobile devices (mobile OS).

By October 2011, Android and iOS mobile operating systems had the biggest U.S. smartphone market share [12], with Android devices being dominant on the worldwide market with 52.5% market share [13]. Unlike current PC operating systems, newer mobile operating systems like iOS and Android are optimized for touch screen interface and run smoothly on lower powered processors, with low quantities of Random Access Memory (RAM). Both, iOS and Android, as well as several other mobile operating systems, offer support for software programs and services called "applications". Applications can be used to add extended ACC functionality to the device, essentially turning them into a non-dedicated AAC device [14]. There are several applications available for symbol based AAC users, but only few complete solutions for communication aid, intended primarily for English speaking markets [15]. Some mobile operating systems have several integrated accessibility options, but they do not cover users which primarily use symbols in communication [16].

Most of new tablets and smartphones have an integrated touch screen, speaker, microphone, digital camera, Bluetooth, Wi-Fi, 3G and GPS modules (Table 1, 2). The majority of mobile operating systems allow access of the application to all of these modules, so AAC applications could enable the user to access all technological abilities of the device. A potential problem might be that several mobile OS developers limit access of the application to change the home screen or to change visual properties of operating systems Graphical User Interface (GUI). This could be a problem for some users, because it requires them to enter menus and start the application using standard GUI. On some mobile operating systems this can be bypassed by using customizable graphic shortcuts on starting screen, eg. "widgets" on Android. Since Android is an open-source OS, device manufacturers have the ability to modify the visual and functional aspects of the GUI significantly, giving them the potential to develop a dedicated AAC device running a mobile OS with the ability of expanding the functionality through additional applications.

Mainstream mobile devices lack switch input for providing alternative input methods using specialized AAC devices, but since applications have access to the Bluetooth module, AAC application developers have the ability to add support for

Bluetooth-enabled switch input devices or other specialized input devices like various keyboards or mice, providing even better accessibility and increasing interoperability between AAC devices and mainstream technologies [6]

4 User Survey

In order to get a better insight into problems that Croatian AAC users are facing when using the solutions available on the market and so as to try to understand better their wishes, needs and requirements, an online questionnaire has been distributed to the parents of current and potential symbol based AAC system users in the period from 15th April to May 27th 2011. The questionnaire consisted of several general questions about children, followed by questions concerning technologies and programs that children use in their daily activities, and regarding the technologies and programs the parents would like their children to use. There were a total of 15 respondents, 11 having a male and 4 having a female child with a disability aged between 5 and 21. Only 3 out of 13 respondents answered that their child uses a dedicated AAC device, only one of whom using a communicator. Parents identified the small size of letters (7 answers) and symbols (6 answers) as main problems with AAC programs that their child is (or was) using (Fig. 2). Foreign language was mentioned third with 5 answers. Only two parents consider that their children have not encountered any problems.

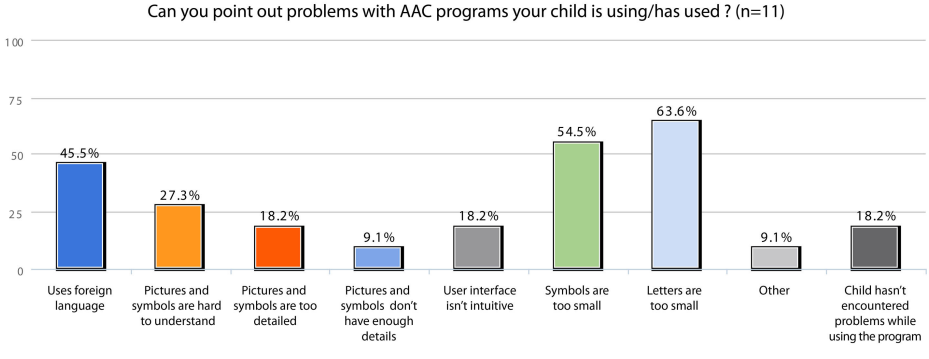

Fig. 2. Problems that users are having with current AAC programs

Currently, children mostly use AAC programs and web pages for entertainment (8 answers) and education (6 answers) and none of the children uses it for online communication (Fig. 3). All respondents want their children to use AAC programs and web pages in the future, demonstrating increased interest for the use in education (10 answers), entertainment and book-reading, but also for online communication, as a communication aid, for drawing and as a navigation aid (Fig. 3).

All parents own a PC with internet access, with only one third of them having at least one smartphone device in their household (Fig. 4). None of the respondents owned a mainstream tablet device.

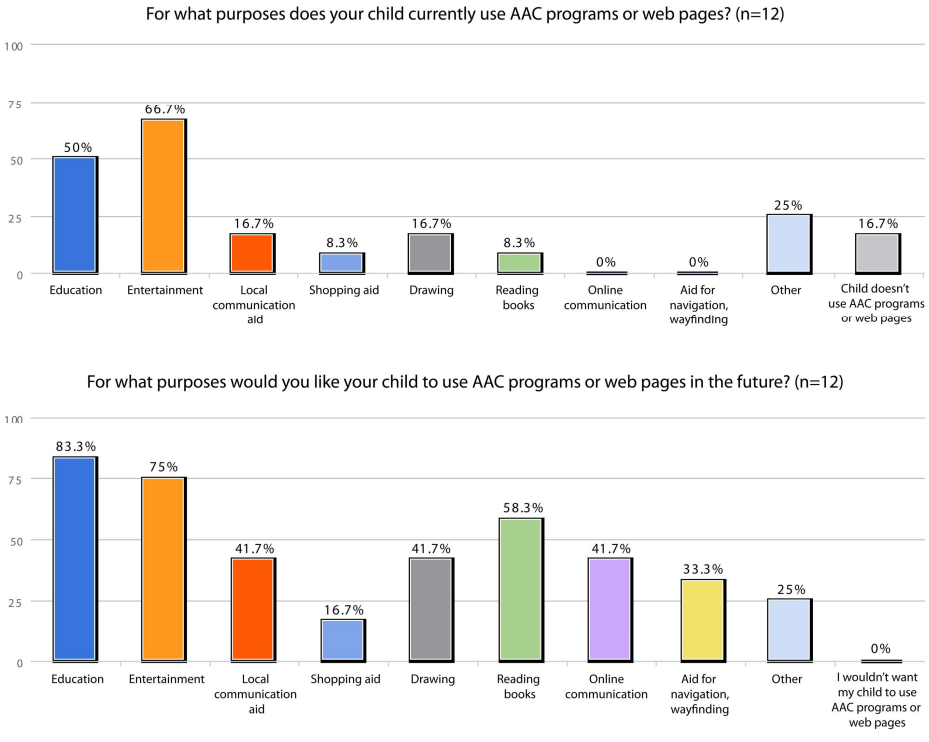

Fig. 3. Current and desired use of AAC programs and web pages

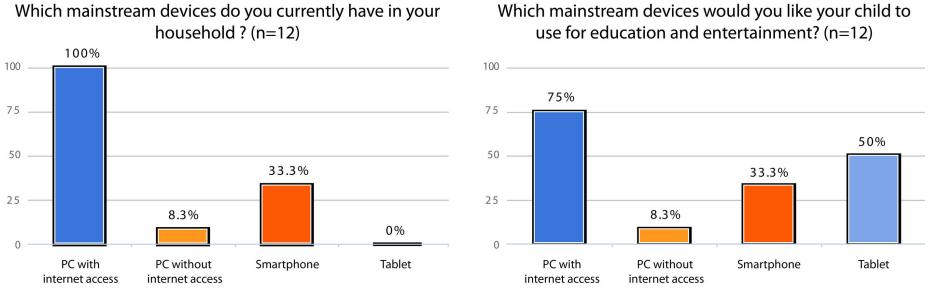

Fig. 4. Mainstream devices that are available to users the household and parents' wishes regarding mainstream devices used by children AAC users in the future

5 Conclusion

In the world where people are "always connected" via mobile devices and communicate and obtain information online, it is important to help the people with various types of disabilities. The access to these mainstream technologies is fostering their participation in society.

Since the majority of mainstream mobile devices allow adding extra functionality by downloading and installing optional applications, the adding of symbol-based AAC programs and services in that form is a way to expand the accessibility for some users without hindering user experience for others.

The integration of AAC functionality using applications is a step in the right direction since it helps people who use symbols for communication to stay in touch with the latest technological achievements in mobile technology. These AAC solutions should lend itself to the user, but also to the device and its technical characteristics.

The survey of the habits of Croatian children with disabilities shows that there are numerous problems with the existing AAC programs and services, and that parents want their children to use AAC programs more and for wider variety of tasks. There is also a strong wish that the children use mainstream tablet devices.

Current mainstream mobile devices, especially tablets based on Android and iOS operating systems, have technical capabilities of implementing the proposed model of adaptable symbol-based AAC system. So as to develop the system and define its graphical and functional aspects, a further research is necessary. Model prototypes can be used to enable the definition and evaluation of these aspects by potential users.

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