Improving the Outcomes of Children with Autism Spectrum Disorders through User-tuned Content Customization

Margarida Lucas da Silva
Instituto Superior Técnico, Av. Rovisco Pais, 49, 1050-001 Lisbon, Portugal

Abstract

Autism Spectrum Disorders (ASD) are a triad of disturbances affecting the areas of communication, social interaction and behavior, and each subject has very different cognitive and functional characteristics. Especially at young ages and in educational contexts, these limitations can be deeply disabling if appropriate intervention methodologies are not used. Computer aided tools play a major role in the development of adequate educational responses, however, current approaches either focus more on the delivery of rich multimedia content, and less on the customization capabilities, or vice versa, and are unable to explore the individual differences that are specific to each subject with ASD. This work presents a novel approach focused on improving the outcomes of children with ASD, with a special emphasis on communication skills, by exploring the potential of user-tuned content customization to enable children to interact, share opinions and experiences, through a rich multimedia environment. Our research takes into account the needs of both the children and their caregivers, and provides the means to prepare a unique setup for each child, giving the possibility to fully customize the layout and contents. Our approach was evaluated through a set of transversal and longitudinal studies involving real-world users, for which we present a detailed analysis. In the overall, experimental results have shown that our proposed approach leads to improved outcomes and higher engagement of the children in the educational process.

Keywords: Autism Spectrum Disorders, Customization, User-Tuned Content, Rapid Application Development

1 Introduction

Children with Autism Spectrum Disorders (ASD), exhibit a range of specificities in terms of their cognitive and communicative skills that need to be appropriately addressed. Each case is unique, and the ability to define user-tuned content is fundamental to the widespread of adequate work strategies with the children, based on their individual interest. Information and Communication Technologies (ICT) based strategies have enabled a huge leap in the field. However, only standardized content and application models are available, which might not be the best approach, as each children or group of children has individual needs. Nowadays, web-based applications play a major role in content display both for online

and offline use, becoming more accessible with time, and giving the possibility to develop tools that easily meet users needs. The intrinsic features of web technologies, makes them a straight forward and complete solution for easy and fast customization to new requirements in terms of needs within the target user group. Also, the constant development of new ways to be more interactive and efficient makes web technologies, a good solution to tackle problems that were typically linked to more traditional monolithic applications.

In our work, we are going to analyze a multimedia platform developed using web standards that focuses on children individual interests. Existing tools targeted at children with special needs try to be more accessible and provide educational content. However, children often lose motivation to use it, since they don't find it appealing enough, don't relate to any content inside, or even find content that might stress them in some way. Our tool gives the possibility to tune the presented contents to the children' interests, and to evaluate how these can be used to motivate them to use an application that can produce positive outcomes in an educational context. Our hypothesis is that combining the use of a computer, which as mentioned before causes curiosity, with content customization, can greatly help in making educational strategies more effective by shaping them to the unique personality of each individual, thus providing a better way to stimulate peer communication.

The rest of the paper is organized as follows: Section 2 provides an overview of ASD; Section 3 describes the background of our work; Section 4 introduces Troc@s and the problems to address; Section 5 introduces the proposed approach; Section 6 shows the evaluation with tests from tutors and children; and finally Section 7 outlines the main conclusions.

2 Autism Spectrum Disorders

ASD are a group of developmental disabilities, comprising Classic Autism, Asperger syndrome and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) [1]. Their symptoms range from moderate to severe, varying among patients. In 1979, Lorna Wing carried out an epidemiological study and realized that there were a transverse triad of impairments: a) impairments in social interaction; b) impairments in language and communication skills; and c) social imagination, which is an inability of imagining things they didn't experience yet. These impairments are the currently basis used to diagnose ASD [2]. Furthermore, a behavior pattern suggests restrictive, repetitive and stereotyped interests and motor mannerisms (e.g hand or finger flapping).

There are also other characteristics often highlighted in autistic patients but which are not always present, such as an exceptional memory, superior skills in attention, and perception and unusual sensory perceptions. All patients show several differences between their disabilities, creating a unique personality that requires looking at each child as a different case. Because they have restricted interests and can become very fixated on them, these restrictions might be used in their benefit. Boyd developed a study [3] where he compared the effects of circumscribed interests to less preferred tangible stimuli on the social behaviors, and the results showed an increase in social interactions in tests with circumscribed interests. These results were important since they state how children become more interested and motivated when contents are fitted to then.

3 Background

Overall, existing approaches and methodologies proposed to date focus on self-development and don't show much concern towards enabling children to communicate with each other, or adapting the tool to the user, or deliver any kind of courseware. Most of the work found to data is inspired in Picture Exchange Communication System (PECS), which is a simple system that children understand, and is simple to use, and even in the cases where user-tuned content customization is possible, the procedures to do so require the tutor to acquire specific knowledge and the customization options are limited. But all of the current studies explore the use of multimedia, which shows us that this is the most effective way of capturing the attention of the children and help in the development of new communication skills.

Looking more closely at some studies more focused in the user customization, we have De Leo and Leroy [4] that developed a smartphone application to form messages. These messages could have text or images, and all images could be customizable, giving the possibility to the children to choose their own images. Ismail and Omar [5] created an application that gave the possibility to decide what kind of content was of interest to include (from a restricted list), and visually where to place it. Morris and Kirschbaum [6] created an algorithm to find images in the Internet that were of the interest to the children, to be used in any kind of application. Rahman and Naha [7] created an application running in a network, in which a tutor can show pictures of objects to send messages, and the pictures of that object in the children's computer may differ according to their preferences.

These examples show the ecosystem and difficulty in tuning the application to each child; as a growing concern in the software development, now some involve the user in the design process [8], or give customization possibilities. Despite the recent effort, current tools are still not able to meet the needs of tutors and children, in terms of adjusting the application content and visual aspect to the preferences of the children. In Table 1 we can see all options available in these studies. As we can see, none of these approaches supports all these functionalities, showing some limitations. In our tool, we will give all the options described in the table, making it 100% customizable.

Table 1: Survey of tool options for the user

	Multimedia content	Custom Content	Custom layout	Tool Configuration	User-centred Design
[4]	✓	✓	✗	✗	✗
[5]	✓	✗	✗	✓	✗
[6]	✓	✓	✗	✓	✗
[7]	✓	✓	✗	✗	✗

New possibilities have emerged with touchscreen technologies (e.g. smartphones and tablets), bringing new opportunities to users (usually paid), and mostly designed to help parents in the interaction with their children. Taking advantage of the touchscreen, which allows a more natural interaction for children with cognitive and motor impairments, most applications allow children to communicate through images, to create storyboards, or to reproduce content of their choice using sound.

4 Exploring Communication Enhancement via ICT

This work builds on the findings of a special education teacher, in the context of her master's thesis of speech therapy [9]. She was a teacher of 5 children with 11 and 12 years old diagnosed with ASD, and felt the need to have a platform to motivate them to communicate with each other, since most of them never did. While searching in the state-of-the-art for tools to use with the children, she was unable to find one that would be suitable for the needs of all of her students, and able to help develop their communication skills. She also showed concerns in preparing the tools for children, since some were too complex to adapt, or simply didn't allow any change to be made to the content or layout. In her master's thesis [9], she wanted to evaluate how communication could be positively developed in children; as such, we devised a software platform with the activities she felt to be most suitable for the children, namely: videos, images, music, stories, message board, *likes* and *dislikes*, and a link to Microsoft Photo Story[1]. The communication between peers would be ensured with the local message board and preference sharing (*likes*/*dislikes*). Based on these needs, we developed an all-original software platform capable of supporting her study; this platform was called Troc@s. The full description of this system is available in [10].

After the experimental tests for the master's thesis [9], Troc@s showed some issues concerning data persistency, showing poor performance, and some problems with content visualization.

This version was mostly focused in the special education teacher' needs for her thesis, and also her student needs. In order to improve Troc@s and ensure the necessary evolution of the platform, we needed not only to solve the problems we found during the experimental study, but also to understand the full needs of children with ASD. For that we needed to understand what tutors need, in order for them to properly take care of the children. For that we conducted a survey to understand the tutors' needs, and the results show us that most tutors are concerned with helping children in further developing their skills.

The skill that most tutors found the need to work is mainly communication, which we can deduce to be the bigger constraint in the school, everyday. In the overall, tutors show a great need for novel approaches such as the ones addressed by our work, and also show a large openness and preparation to change their routines to accommodate new tools that are suitable for everyday use by the children. This survey showed us that Troc@s answers several of their needs with entertainment components such as watching images, video, or listening to songs. Still, they point out communication and the full adaptation of the platform to the child as very important aspects, and the original version of Troc@s was very limited in allowing specific customization for every child, and with the message board approach being highly limitative for the work that could be done with the children.

5 Accounting for Individual Differences in Children with ASD

In the scope of our work, we developed myTroc@s.net, an evolution of Troc@s that builds on the seminal work initiated by our group to account for the individual differences found in each child with ASD, and propose new methodologies both for the children and their tutors. myTroc@s.net improves on all major methodological and technical issues that were found in the preliminary experiments with Troc@s.

[1] http://www.microsoft.com/en-us/download/details.aspx?id=11132

We still explored the Operating System (OS) File Management System (FMS) approach already available in Troc@s, because this is the most natural and straightforward approach that the tutors can follow to customize the platform, and adapt it for the children. Since we used the previous experience with Troc@s as a starting point for our novel approach, all the activities already developed are preserved. In myTroc@s.net we focused on improving the user experience for children, making the customization process easier for the tutors, and integrate the feedback obtained through the tutor survey, more specifically, giving the possibility to create several customization possibilities for all children by creating profiles, enabling a more engaging communication experience for the child, making the interfaces less confusing for them, and overcoming the limitations introducing by the standalone approach that was followed in Troc@s. Finally, in myTroc@s.net we also focused the development of tools to quantitatively and objectively assess the system usage and behavior of the child while interacting with the platform, rather than recurring to the traditional empirical or observation-action methods as adopted in Troc@s [9].

The full description of myTroc@s.net framework and functionalities is available in [11].

6 Experimental Evaluation and Results

The primary goal of our work was to understand if user-tuned content and interface customization can contribute to increased motivation and improved outcomes when tutors use computer-aided educational strategies to support their work with children with ASD. In this chapter we will present the results of our experimental evaluation of myTroc@s.net in a real-world context to assess: a) If the platform is sufficiently intuitive and easy-to-use; b) If the tutors can easily use the framework and provide user-tuned content to address the children needs; and c) If our proposed approach can actually lead to better outcomes with the children. We present the experimental procedure adopted for each experiment, and the corresponding results; in Section 6.1 we describe an experimental evaluation to the attention detection module, in which we try to assess if the module is viable asset to further engage the child throughout the use of the platform; in Section 6.2 we address the tutors' task and the platform usability evaluation results, providing a discussion of the main findings, then in Section 6.3 we will describe the test procedure used to evaluate the effect of customization and outline the main conclusions.

6.1 Attention Management Module

Our goal with the attention detection module was to analyze the child attention while using myTroc@s.net. This technique was tested in an experimental evaluation where we automatically try to recover the user's attention when he looks away from the computer by triggering an auditory feedback stimuli, and evaluating if this kind of feedback contributes to have the children more engaged in their activities with the platform.

For our tests, we evaluated 12 children over the course of 24 sessions, 2 per user, in 2 computers (both with the same look-and-feel and content configuration): an experimental group of 6 children used the platform on one computer for a total of 12 sessions, with the automated attention management module activated to try and recover the child's attention; a control group of 6 children used the platform on the other computer for a total of 12 sessions, with the attention management module disabled. This

setting allows us to assess the impact that the attention detection and real-time acoustic feedback has in re-engaging the child and changing the focus behaviors, after the child's attention is diverted.

With the acoustic feedback to trigger the child's attention, the results show that the users look away from the screen less times, distracting themselves less often. Also, they have less momentary distractions (below or equal to 3 seconds without looking at the computer screen), and less absent distractions (more than 30 seconds without looking at the computer screen). Despite the fact that there is a higher number of sessions in which the child is focused from start to finish in the experimental group, in control group they regain their attention more quickly, which might have resulted from external action of the tutor in instructing the child to return to an attentive state.

This experimental analysis allowed us to conclude that the attention detection module would be an important add-on while evaluating the children in the next part of our work, since in this way we can determine if the attention patterns of the children change when the platform is customized and user-tuned content is used.

6.2 Platform Customization Usability

Results have shown our approach to be adequate for regular use, as shown by the average completion time and low number of errors; an experienced user takes 3 to 4 minutes in the customization task. Even with the FMS method some users don't feel confortable using the computer as shown by the 3 cases with higher completion times. When inquired about their computer proficiency, most caregivers said that they were accustomed to using the computer, but they did a very limited usage of it in their routines. Results let us conclude that the FMS is a natural process, completely familiar to most caregivers.

During the test, we observed the caregivers difficulties, and most of them were related with the concept of user profiles. All participants knew how to navigate in the folders, handle the files. Still, all of them struggled when dealing with the profiles. Most seemed to easily forget the differences in the purpose of each profile folder, and how to operate them. The results in the System Usability Scale of 74, lead us to believe that the biggest problem is bound with the training and motivation towards the use of the platform, which requires some apprenticeship.

This was especially noticeable in the older users. While observing and talking with them, we realized that they had their routines with the children settled for some time, and despite agreeing with the lack of appropriate tools, when confronted with one, did not seem interested enough. Most of the users reported that the system is not complex, but they need some training to use the tool. In the overall the results are positive, showing that most users find the system is well-integrated and simple to use and would consider using it frequently, which is a good indicator of their satisfaction towards this approach. Future work will focus on simplifying the folders structure for profile management in a way that better promotes the ability to remember the process and organization. Further results and discussion are available in [12].

6.3 User-Tuned Content Effect

To evaluate if the customization has any effect on the outcomes of children with ASD when computer-aided educational strategies are used, we asked their tutors to perform the customization that they

Table 2: Summary of the myTroc@s.net aspects that were customized.

Cases:	1, 2 and 3	4, 5 and 6	7, 8 and 9
Groups:	Group E (Experimental)	Group E (Experimental)	Group C (Control)
Layout:	None	Menu icons and Background images	None
Content:	Images, Videos, External Files and Apps	Images	None

Table 3: Descriptive statistics for the overall sessions analysis.

	Total number of users	Total number of sessions	Sessions ratio	Total duration of all sessions	Average session duration	Standard deviation
Group E	6	135	22.5	25:24:19	00:11:17	00:23:02
Group C	3	32	10.6	8:24:57	00:15:46	00:31:26

found more appropriate for each child. In total the tests involved to 9 children, among which 6 used a customized version of myTroc@s.net with user-tuned content (the experimental group), and the other 3 used the platform with the default layout and content (the control group). For simplicity, we will refer to the children that used the customized version of the platform as Group E (Experimental), and to the children that used the non-customized version of the platform as Group C (Control).

To guarantee that we can perform the tests without any problems and effectively retrieve our results, we decided to base our study on the logs produced by the framework. We also used the attention detection module to characterize the children's attention levels.

The sessions occurred over the course of 15 weeks, and respected the time slots that children have available to use the computer. The children were able to choose if they wanted to use myTroc@s.net or not, given that they use the computer freely without the constant supervision of their tutor. If they didn't use myTroc@s.net, the tutor invited them to do so, but if the child still didn't want to use the platform, he/she was not obliged.

We asked the tutors to customize the platform with the user-tuned content that they thought would be the best for each child, given that tutors have a deep understanding of the preferences of the children they are following. We can see a summary of what was customized in each case in Table 2.

In these tests we were seeking to assess if there were any differences in the behavior or use patterns of our proposed methodology between children using the platform with user-tuned content and customized look-and-fell (Group E), and without customization (Group C). The existence of differences would in itself be positive, because if Group E and Group C had shown similar results, that would mean that using customized content was no different than using non-customized content.

The average number of sessions per user has revealed to be higher in Group E, which tells us that children in this group return more frequently to use myTroc@s.net. We can see these results in Table 3. Looking at the session duration, on average, both groups have short sessions, which seems to be consistent with one of the characteristic traces of children with ASD that is to quickly loose focus. Still, the average session duration is lower in Group E; as previously stated, we believe this to be caused by the effectiveness while performing the activity, that is, children find content of their preference faster, and thus, might end the session quicker as well. Children, in which the contents aren't customized to

their preferences, need to search more thoroughly for content inside each section; some might quit the platform, unmotivated, but the majority remains. Still, children in this group don't seem to wander around different activities in the platform, because the number of loaded sections is significantly lower, further reinforcing our previous conclusion that children without user-tuned content employ a more thorough search for contents, and also showing us that children don't navigate so enthusiastically in Group C, as in Group E.

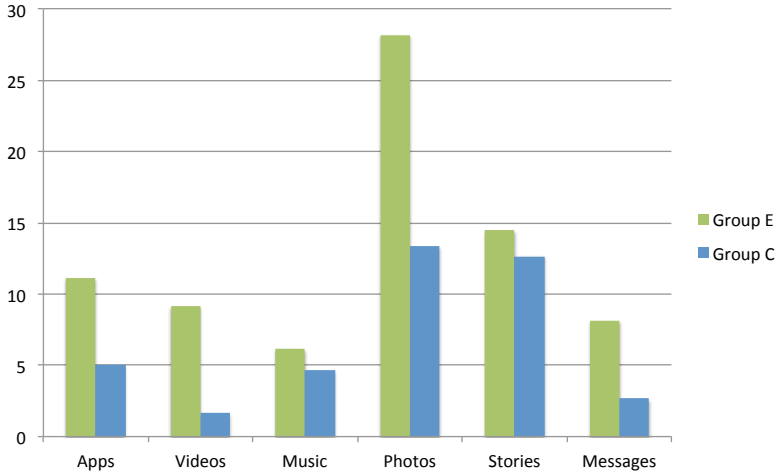
To support these findings we can also look at the attention results, where the children from Group E were able to perform completely focused sessions in 12% of the cases, while in Group C, we've seen 0% of sessions with focus. Also, it is important to see that there is a difference in the focus patterns among the children from Group E; in the cases where children have layout and content customization, they show positive results by keeping attention during a whole session, whereas in the cases within Group C where only the content was customized, the same pattern does not occur. Based on the attention results, the layout customization according to the children preferences seems to help children to keep the focus on the platform for longer periods.

Overall, the platform seems to have led to differentiated behavioral patterns and improved outcomes in the children that used user-tuned content and customized look-and-feel. Regarding the communication patterns, although children from Group E tend to access more often the messaging activity, there are no visible differences in the amount of messages exchanged nor in preference sharing. Regarding the messages, tutors stated that they wouldn't customize the pictures made available on the messaging interface, because they were not sure of what alternative content could be more beneficial for them. As such, they preferred to leave the default images; this represented a minor setback to our work, because it was clear that even the tutors are not able to fully understand how to take advantage of some of the customized content to guide their students. Partially we believe this is due to a lack of awareness in the communication field, namely in the understanding the kind of symbols that could be helpful for the children in a semiotics perspective. Nonetheless, we also believe that is again a motivational issue, where sometimes the tutors simply don't want to take the time to research for which symbols would be more easily recognized by each child.

We can see that the customization brought some changes in the behaviors of the children from Group E when compared to the children of Group C, more specifically, we point out the focused percentage, where we can clearly see that in Group C children were unable to keep the attention in any session, whereas in Group E half of the children exhibited multiple sessions where the kept focused from start to finish. This increased level of focus shows that children might have been more engaged while using the platform, and as such, benefit more from the activities when the content is customized, which can improve their communication or social skills with continued use. This was also aligned with the feedback provided by the tutors, where they talk specifically about two children that when they found their favorite cartoons in the platform repeatedly asked to use myTroc@s.net and spent a lot of time just watching the cartoons pictures. This happened also with some of general content available by default in the platform; for example, there was a specific child from Group E that enjoyed 2 videos in the default content, and kept coming back to the platform to watch those videos.

Children in Group E used more of the activities that were customized in the platform, like images, videos and external apps as we can see in Figure 1. These activities were the most customized by the tutors, and we can clearly see that the usage intensity is larger in Group E than in Group C. Furthermore, activities like stories or music (sections that weren't customized) we see that there is no apparent difference

Figure 1: Number of loaded application sections per user.



in the usage patterns, even though it is slightly higher in Group E; this, we believe, is related with the overall motivation that children in Group E feel towards the use of myTroc@s.net.

7 Conclusions

Based on the knowledge gathered from prior work, and on commercially available tools, we present a novel methodology materialized by a platform and framework called myTroc@s.net, which emerged from the real-world needs of special education teachers. Our approach is focused on customization as a way of potentiating the capabilities of each child and improve their overall outcomes, by introducing the concept of profiles as a way of enabling the full customization of the platform for each child, together with a Rapid Application Development (RAD) / Rapid Application Customization (RAC) framework designed to streamline the customization process for the tutors. Besides the children, we also focused our attention on the tutors, since they are the ones that interact directly with the children, and prepare the individual profiles for the children.

The results for the tutors are positive, showing that most users find the system is well-integrated and simple to use and would consider using it frequently, which is a good indicator of their satisfaction towards this approach.

Regarding the children we were able to see that our approach leads to increased attention and motivation, and results lead us to believe that if the platform delivers helpful and positive functionalities that allow children to compensate a few aspects of their impairment, the customization made to address their preferences can definitely improve their outcomes.

Bibliography

[1] C. P. Johnson, S. M. Myers, and the Council on Children With Disabilities, “Identification and evaluation of children with autism spectrum disorders,” *Pediatrics*, vol. 120, no. 5, pp. 1183–1215, 2007.

[2] L. Wing and J. Gould, “Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification,” *Journal of Autism and Developmental Disorders*, vol. 9, no. 1, pp. 11–29, 1979.

[3] B. A. Boyd, M. A. Conroy, G. R. Mancil, T. Nakao, and P. J. Alter, “Effects of circumscribed interests on the social behaviors of children with Autism Spectrum Disorders,” *Journal of Autism and Developmental Disorders*, vol. 37, no. 8, pp. 1550–1561, 2007.

[4] G. De Leo and G. Leroy, “Smartphones to facilitate communication and improve social skills of children with severe autism spectrum disorder: special education teachers as proxies,” in *Proceedings of the 7th ACM International Conference on Interaction Design and Children (IDC)*, pp. 45–48, 2008.

[5] A. Ismail, N. Omar, and A. Mohd Zin, “Developing learning software for children with learning disabilities through Block-Based development approach,” in *IEEE International Conference on Electrical Engineering and Informatics (ICEEI)*, vol. 1, pp. 299–303, 2009.

[6] R. R. Morris, C. R. Kirschbaum, and R. W. Picard, “Broadening accessibility through special interests: a new approach for software customization,” in *Proceedings of the 12th ACM International Conference on Computers and Accessibility (ASSETS)*, pp. 171–178, 2010.

[7] M. R. Rahman, S. Naha, P. C. Roy, I. Ahmed, S. Samrose, M. M. Rahman, and S. I. Ahmed, “A-class: A classroom software with the support for diversity in aptitudes of autistic children,” in *IEEE Symposium on Computers & Informatics (ISCI)*, pp. 727–731, 2011.

[8] P. Francis, S. Balbo, and L. Firth, “Towards co-design with users who have autism spectrum disorders,” *Universal Access in the Information Society*, vol. 8, no. 3, pp. 123–135, 2009.

[9] C. Simões, “Sistemas multimédia para o desenvolvimento da competência comunicativa de crianças com Perturbações do Espectro do Autismo,” Master’s thesis, Instituto Politécnico de Setúbal - Escola Superior de Saúde, 2011.

[10] M. L. da Silva, H. P. da Silva, C. Simões, F. Botelho, and T. J. Guerreiro, “Rapid Application Development using Web Technologies - An Application to Communicative Competence Promotion of Children with ASD,” in *Proceeding of the 4th International Conference on Health Informatics (HEALTHINF)*, pp. 583–586, 2011.

[11] M. L. da Silva, D. Gonçalves, T. Guerreiro, and H. Silva, “A Web-based Application to Address Individual Interests of Children with Autism Spectrum Disorders,” *Procedia Computer Science*, vol. 14, pp. 20–27, 2012.

[12] M. L. da Silva, D. Gonçalves, and H. P. da Silva, “Simplifying User-Tuned Content Management in Assistive Software,” in *Proceedings of the 12th European AAATE Conference (AAATE)*, 2013.