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User-tuned Content Customization for Children with Autism Spectrum Disorders

Margarida Lucas da Silva[a,b], Daniel Gonçalves[a,b], Hugo Silva[c]

[a] *Instituto Superior Técnico, Av. Rovisco Pais, 49, 1050-001 Lisbon, Portugal*
[b] *INESC-ID, R. Alves Redol, 9, 1000-029 Lisbon, Portugal*
[c] *Instituto de Telecomunicações, Av. Rovisco Pais, 1, 1049-001 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 and share opinions and experiences, through a rich multimedia environment. Our approach was evaluated through a set of transversal and longitudinal studies involving real-world users. 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.

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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 appropriatly 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,

E-mail address: margarida.lucas.silva@ist.utl.pt, daniel.goncalves@vimmi.inesc.pt, hugo.silva@lx.it.pt

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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 acessible with time, and giving the possibility to develop tools that easily meet user's needs. The intrinsict features of web technologies, makes them a straightforward 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's individual interests. Existing tools targeted at children with special needs try to be more acessible 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 the proposed approach; Section 5 shows the evaluation methodology and results; and finally Section 6 discusses the results and 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 unusual sensory perceptions. All patients show several differences between their disabilities, creating an 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 circumscried interests. These results were important since they state how children become more interested and motivated when contents are fitted to then.

3. Related Work

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 an augmentative communication system, developed to help subjects in quickly acquiring a functional means of communication[4]. It is versatile and inexpensive, since tutors can create and print the pictures that the children need. This tool is mostly used by people with speech limitations, with the need to communicate and understand actions in an effective way. Although a simple approach, this is the general base for most systems and tools aimed at supporting children in communication.

Looking more closely at some studies more focused in the user customization, we have De Leo and Leroy[5] 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[6] 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[7] 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[8] developed 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[9], 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
De Leo and Leroy[5]	✓	✓	✗	✗	✗
Ismail et al.[6]	✓	✗	✗	✓	✗
Morris et al.[7]	✓	✓	✗	✓	✗
Rahman et al.[8]	✓	✓	✗	✗	✗

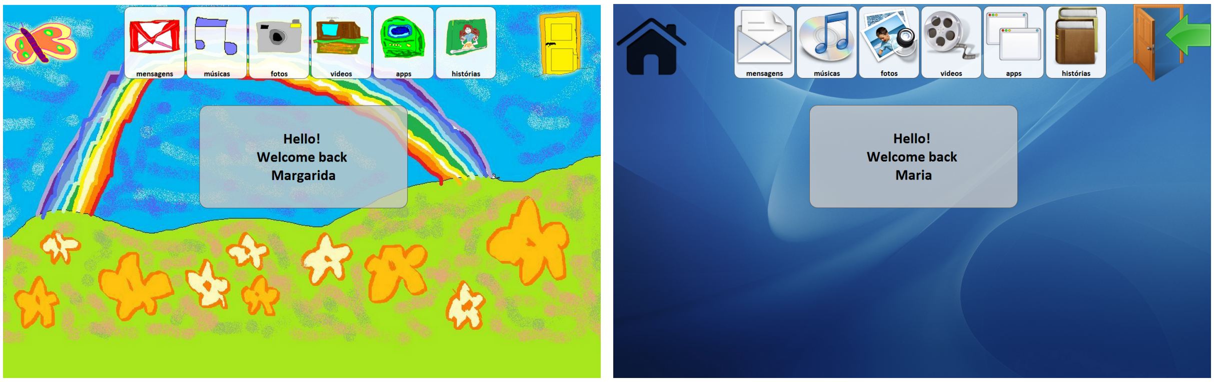
New possibilities have also emerged with touchscreen technologies (e.g. smartphones and tablets), bringing new opportunities to users (usually paid), and mostly designed to help parents in the interaction with their children. Taking advantage of the touchscreen, which allows a more natural interaction 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. Accounting for Individual Differences in Children with ASD

In the scope of our work, we developed myTroc@s.net, an evolution of our previous solution, Troc@s building on that seminal work initiated by our group to account for the individual differences found in each child with ASD, and proposes new methodologies both for the children and their tutors[10]. myTroc@s.net improves on all major methodological and technical issues that were found in the preliminary experiments with Troc@s.

myTroc@s.net focuses on promoting the acquisition of new competences at the communication level, by using content that is customized for the preferences of each child. Children have the possibility to say what they like or not, and view their peers preferences as well. All activities are focused on the training of communication skills, and are based on multimedia content (photos, music, videos, ...). Furthermore, we provide a message board that uses both text and symbols, to which children can easily relate to and understand, thus facilitating the communication process.

One of the main features of myTroc@s.net is the fact that it enables full customization of the platform to the childs needs, not only in terms of content, but also in the overall appearance and graphic layout, without the need for tutors (teachers, parents, and caregivers in general) to require a vast technological background or proficiency. We can see an example in Figure 1, that illustrates a customization of myTroc@s.net with two different profiles. This way tutors or the users can set the look and feel of the activities so they can understand or feel more comfortable in using the tools. For the customization process we took into account the fact that tutors may not be technologically proficient, which led us to do a user centered design approach geared to explore the simplest and more familiar procedures in the tutors perspective. Our approach uses the Operative System (OS) File Management System (FMS) to do the content management, using the "My Documents" metaphor, available in any OS. Tutors can create different profiles by just creating new folders and assined them to corresponding children. This way the tutors only need to copy and paste content to intuitively defined folders (e.g. "Images" or "Music") and the platform automatically prepares the content for visualization. Our usability tests have shown positive results, where tutors reveal high levels of satisfaction[11]. The full description of myTroc@s.net framework and functionalities is available in a previous publication[12].



(a) Profile customized for user A.

(b) Profile customized for user B.

Fig. 1. Example of customized profiles in myTroc@s.net.

5. 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 section 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 5.1 we will describe the test procedure and methodology used to evaluate the effect of customization; in Section 5.3 we present the test results and finally in Section 6 we discuss the results and outline the main conclusions.

5.1. Methodology

To evaluate if the customization has any effect on the engagement outcomes of children with ASD when computer-aided educational strategies are used, we asked their tutors to perform the customization that they found more appropriate for each child. In total the tests involved 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 explained in Section 4.

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 mentoring. We can see a summary of what was customized for each case in Table 2.

5.2. Metrics

In order to record the actions and interaction patterns of children while using the myTroc@s.net platform, our framework was fitted with a logging mechanism, which enables us to derive objective measurements that can be used

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

to characterize the experience of the child when using the platform. For each user, a new log file is created every time he logs in, and the current date and time is assigned as the file name. The framework produces 6 different types of logs through which we can audit the child's behavior; per user session it records:

- **Apps:** Saves the date and time in which an external app was launched, and saves the full path of the loaded applications.
- **Face Detection:** The application uses the camera from the computer to detect the position of the child's head, to see if the child is looking at the computer or not, and thus, paying the necessary attention to it. In the log file, each line has two columns, and represents a change in interaction status from attentive to distracted and vice-versa, the timestamp has the time in seconds since the Epoch and is saved on the left column, while on the right column, a Boolean value is stored, where 0 is the state in which the child looks away, and the 1 is the state in which the child looks back at the screen (attentive).
- **Likes:** Saves the date and time of every *like*/*dislike* selection that the child made using the preference sharing pane presented along with each content item, and lists the full path of the chosen content item together with the type of selection (whether it was a *like* or *dislike*).
- **Activities:** Saves the date and time in which a given activity was loaded, with the indication of the type of activity (e.g. photos, videos, music...) that was loaded and what section did the child visit during the session.
- **Messages:** Saves the date and time in which the message was sent, together with the indication of the recipient peer, the number of characters in the message, and the number of pictures included in the message.

These logs are created to record every activity of the child while using the the platform, and used in our study to quantify the children's communicative and behavioral patterns. Combining all information available in the logs, we can have an objective and quantitative perception of the child's behavior and perform group analysis in order to determine the effect of user-tuned content in the educational strategies and outcomes of children with ASD.

5.3. Results

In these tests we were seeking to assess if there were any differences in the behaviour 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 myTroc@s.net. We can see these results in Table 3. Looking at 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; 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 for which the content isn't customized to their preferences need to search more thoroughly for content inside each section; some might quit the platform, unmotivated, but the

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

Table 4. Percentage of focused sessions by groups.

Focus	
Group E	Group C
12%	0%

majority remain. 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 in Group C don't navigate so enthusiastically as in Group E.

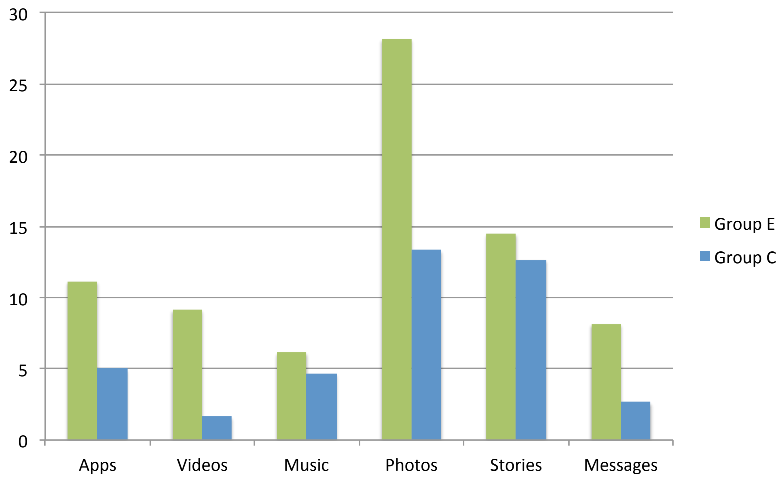
To support these findings we can also look at the attention results in Table 4, where we can see that children from Group E were able to perform completely focused sessions in 12% of the cases, while in Group C, that never happened (0% of sessions). Also, it is important to see that there is a difference 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.

6. Conclusions and Discussion

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 nor 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 focus 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 the 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.

Fig. 2. Number of loaded application sections per user.



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 2. 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, in activities like stories or music (sections that weren't customized) we see that there is no apparent difference 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.

In this paper 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. We achieve this goal 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.

Looking at the tests applied to 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.

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