

# Adaptive web-based educational application for autistic students

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## ABSTRACT

Adaptive web-based applications have proven successful in reducing navigation and comprehension problems in hypermedia documents. In this paper, we describe a toolkit that is offered as an adaptive Web-based application to help autistic students incorporate to high education. The toolkit has been developed using a popular CMS in which we have integrated a client-side adaptation library.

The toolkit described here was tried out during workshops with autistic students at Leeds Becketts University to gather (mostly qualitative) feedback on the adaptation and privacy aspects of the Autism&Uni platform. That feedback was later used to improve the toolkit.

## CCS Concepts

•Information systems → Web applications; •Social and professional topics → People with disabilities; •Security and privacy → Privacy protections;

## Keywords

adaptation, autism, learning styles, privacy

## 1. INTRODUCTION

In this paper, we demonstrate an adaptive Web-based application developed for the Autism&Uni<sup>1</sup> project. It has been created with a tool that combines a popular CMS, namely WordPress<sup>2</sup>, and a library called WiBAF [12] that enables client-side adaptation and that is being developed at the Eindhoven University of Technology (TU/e). Although WiBAF + WordPress integration is generic, meaning that it can be used for creating adaptive applications in different domains, so far we have only used it in the educational context. Apart from the Autism&Uni project we used it in our first year course on Design-Based Learning Hypermedia for creating the “First Aid Kit” for students entering the university.

Autism&Uni is aimed at widening access to higher education for autistic students by providing a toolkit that can help them overcome the challenges they may face when going to university. The goal is to give students a taste of how higher education works and how to cope with the physical university environment before they start

their study. This toolkit<sup>3</sup> is offered as an Adaptive Web-Based Application to autistic students, but also to non-autistic students that might find it useful.

The adaptive functionality differentiates in *how* the information site presents itself to autistic and non-autistic students, but in the end the toolkit provides the same information to everyone. The adaptive functionality offered in the toolkit presented here is based on learning styles and user history.

Adaptive Hypermedia is a research field that can be traced back to the nineties [3, 4]. It has become more complex since then and several frameworks have been developed. They aim to ease the development of these kind of applications. Some good examples of those frameworks are AHA! [6] or GALE [17].

Learning styles refer to the different ways a person can learn. There is previous research on adaptation to cognitive/learning styles and how these can be incorporated into Adaptive Hypermedia Systems and e-learning platforms [16, 18]. While adaptation to learning styles is useful in every e-learning platform, this is specially important in our use case scenario with autistic students as we showed in our previous work [5, 13]. Autistic students show problems linking concepts and therefore, adapting the content to their specific needs can be of great help.

In this demonstration we will showcase the integration of WiBAF and WordPress in several ways. We will show how we apply adaptive hypermedia and learning styles to a toolkit targeted at helping autistic students succeeding in their transition from high school to university. However during the demo session we will also showcase some parts described in our previous work on authoring of adaptive web-based applications with our tool [14].

The remainder of this paper is structured as follows: We describe what autism is and why adaptation to adults on the autistic spectrum is important in Section 2 and then we describe the specific actions taken in our toolkit in Section 3. Section 4 measures the overhead that this integration causes compared to a CMS without any adaptation. Finally we conclude and propose future work in Section 5.

## 2. ADAPTATION FOR AUTISTIC STUDENTS

Adaptation for autistic students is first and foremost concerned with adapting to differences in cognitive abilities. Within this project in particular, we focus on comprehension between autistic and non-autistic students. Autism is often described as a “spectrum disorder”

<sup>1</sup><http://autism-uni.org/>

<sup>2</sup><https://wordpress.org>

<sup>3</sup><http://www.autism-uni.org/toolkit/>

der” because the condition affects people in many different ways and to varying degrees. In our previous work [5] we discussed the “spectrum” and indicated that within the project we are mainly considering students who are of average or advanced intellectual abilities, academically capable and able to communicate effectively in most situations. Traditionally this group would have been referred to as being “high-functioning” or having Asperger syndrome [2, 10], although these labels are both imprecise and considered offensive by many autistic people and other stakeholders [9]. Therefore, in the remainder of this paper we will use the term “autistic students”.

Autism is often called a “hidden disability”, with few physical signs of the student having difficulties until a crisis is reached. This can make it difficult for autistic students to have their needs fully met, as they experience doubts about their condition, demands to justify their requirements from staff as well as from student peers [1]. And this is in addition to the social and communication difficulties common to autism.

With the right support and encouragement, however, autistic students can develop their full potential at university and lead full and independent lives. One of the most accomplished and well-known adults with autism in the world is Temple Grandin, an American professor of animal science at Colorado State University (see her TED talk<sup>4</sup>), but this is just one of many more examples.

Comprehension disturbance makes it difficult for autistic people to make semantic connections between the topics that they study while generally speaking non-autistic people do not have this problem. Autistic people are good at “seeing trees in the forest”, they can spot details but may have difficulties “seeing the whole forest” and developing critical thinking skills [2]. On the other hand, many autistic people have specific strengths such as an ability to maintain intense focus, to think rationally and logically, to adopt unconventional angles in problem-solving or to spot errors that others may overlook [7, 11]. All these are valuable attributes in higher education students, and the strengths of autistic people as professionals with a high work ethic are increasingly recognized by business world-wide, e. g. in technical and scientific areas and also in the humanities and the arts<sup>5</sup>.

In order to provide effective adaptation, we utilize the specific characteristics and preferences of the user in three different learning styles [8], i. e. where is the user located in the: visual vs. verbal axis, global vs. analytical axis and active vs. reflective axis. We make use of the user history as well. These variables together with the adaptation effects provided by the toolkit, have been described in our previous work [5].

A secondary but also important aspect of performing adaptation in the presence of autistic users is the heightened awareness of (and anxiety for) the user modelling involved, in comparison with people outside the autistic spectrum. Autistic students do not only experience anxiety when entering an unknown environment but also when they realize that their personal and possibly sensitive data are stored on an external computer that they cannot access, when they do not feel their data is kept private or they cannot control it. Fortunately WiBAF stores all user data on the client side (using browser storage) by default. Autistic users may choose to keep this setting, thus guarding their privacy, while other users may opt to share their data in order to enable the server side to perform group adaptation. (We currently do not offer group adaptation but we do offer the user model sharing option.)

<sup>4</sup>[http://www.ted.com/talks/temple\\_grandin\\_the\\_world\\_needs\\_all\\_kinds\\_of\\_minds](http://www.ted.com/talks/temple_grandin_the_world_needs_all_kinds_of_minds)

<sup>5</sup>see <http://goo.gl/71YG14> accessed last time on Tue 16<sup>th</sup> February, 2016

For this specific use-case, we also consider some factors related to the context namely, *where* the student is and *what time* it is. The reason for this is that autistic students often feel lost, they need reminders that tell them where they have to go inside the campus. We are implementing a feature so that they can import events from their Google Calendar. The tool will show a reminder when the student needs to go to a lecture and a link with the instructions to get to the room where she needs to be. This is still under development and not yet part of the generic platform, therefore we will not describe it further. We mention the notification feature because it needs to be developed in order to really help autistic students.

All the information written by experts on autism has been divided in learning objects. A learning object can be defined as a piece or a set of content with a specific learning goal. In order to effectively display the content from our learning objects, we have broken it down into small pieces or fragments with some semantic meaning, from which the student can learn something. In our case, we show an introduction first, we show also a comic strip or an image that shows quotes of students about the topic of the learning object, establishing a context for it. Then some background information is provided to justify the learning object. After that we talk about how the learning object being described is important for the reader and what she should do. We close the learning object with some additional tips, questions to think about and some follow-on reading. Each learning object can also have an alternative video version as well as pre and post-requisites.

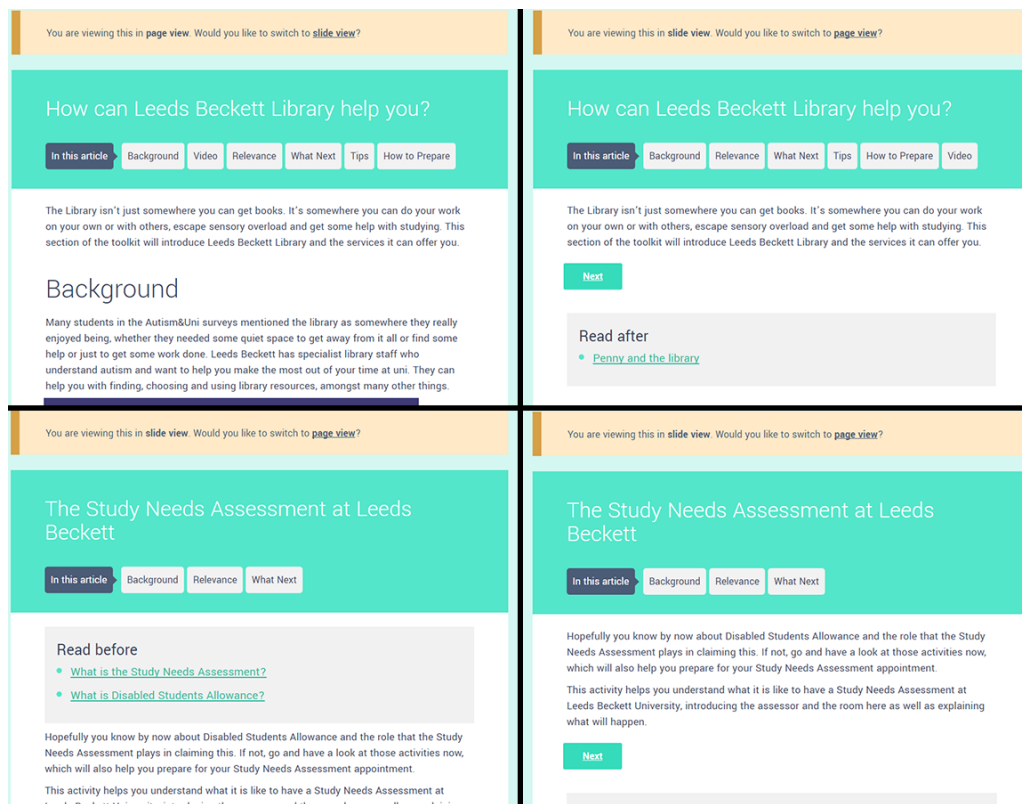
### 3. ADAPTATION EFFECTS

After running workshops with autistic students at the Leeds Beckett University, and trying different alternatives like stretchtext, or reordering of parts that call users to do an immediate action, we have concluded that the following are the most valuable adaptation effects.

- If the user is more visual than verbal, the video version of the content will be shown at the top of the learning object. Otherwise it will be moved to the last (bottom) section of the learning object.
- If the user is more global than analytical, all the sections of the learning object will be displayed on a single page. On the other hand, if the user is more analytical than global, each section will be shown sequentially in one page, in a similar way as in a slide-show.
- Some learning objects have pre-requisites, they require knowledge of some items to be completely understood. These pre-requisites are shown when the user starts to read a new learning object, unless she already fulfilled those pre-requisites. In that case, the pre-requisites block is not displayed in the learning object.
- The learning objects from which the user has already completed are marked as visited. This is done in order to help users remember which items they have already read and which ones they still have to read.

Some of these effects are hard-coded in our adaptation and modelling files, as they refer to the general structure of the content and they are independent of the number of learning objects and their content. Other effects are created dynamically by our framework, when new learning objects are created.

Figure 1 shows two learning object with two different versions of each one. The first learning object is shown on the top-left, the



**Figure 1: Versions of two different learning objects for different types of students (top images), or with different prior knowledge (bottom images).**

version for a global-visual student is depicted and the same learning object for an analytic-verbal student is shown on its right. On the bottom part of the image, a learning object with pre-requisites is shown. On the left, the student has not read the pre-requisites yet, on the right, the student has fulfilled these pre-requisites, and therefore they are not shown again.

#### 4. TECHNICAL PERFORMANCE

Technical performance (speed) is often a problem with adaptive hypermedia systems, which is rarely reported. Some initiatives, including the general-purpose adaptation engine GALE developed at the Eindhoven University of Technology [17] pay special attention to efficiency and can withstand a stress test using hundreds of simultaneous users. Most of the performance problems stem from the adaptation that needs to be computed in the split second between the user clicking on a link and the browser presenting the “next” page. Since WiBAF performs user modelling and adaptation inside the browser it does not face a performance problem because of large numbers of simultaneous users. However there is still a bit of overhead in the server because in the WiBAF+WordPress combination WordPress has to serve (and sometimes generate) code for the browser to execute. We are interested in seeing how both tasks affect the overall performance of the modified WordPress.

We ran a performance test on a MacBook Air laptop together with an Apache Server and a MySQL database. The server was running WordPress version 4.4.2. While this is not the most realistic setup, it gives us an intuition on what the performance could be in a bad scenario (a single machine with limited capabilities) We have measured the time it takes for our modified WordPress to load

several pages of different types (learning objects, the home page, etc.). We did so by using a plugin called P3<sup>6</sup>. Then we compared it to an unmodified WordPress with the default theme, without any plugins (except P3).

The adaptive version of WordPress takes 176 ms to load the site, while the not adaptive version takes 167 ms, that is an overhead of just 9 ms. In the detailed analysis we see that indeed the WiBAF plugin is executed in 9.1 ms while the theme is handled slightly more efficiently in our WordPress than the default WordPress theme.

We also measured the time the client code uses (for user modelling and adaptation). We used the Google Chrome profiler to measure the total JavaScript execution time with our custom WordPress. In this measurements we include not only WiBAF but also JQuery<sup>7</sup>, a popular JavaScript library that is used to manipulate the DOM structures and it is required by WiBAF, and compared that to the default WordPress (not performing any user modelling or adaptation). The execution time of the JavaScript code in our WordPress was 487 ms, against 304 ms for the non-adaptive version. Therefore the overhead we introduce in the client is 183 ms. More than one half of that time (69 ms) is caused by the use of the Indexed DB to store and retrieve data from the user model.

In total, we quantify that making a WordPress adaptive costs 192 ms per request. The page will be served with a delay of 9 ms and adapted in 183 ms. In total the page is served and adapted in 663 ms. According to a study in 2004 [15], users consider a waiting time of around 2 seconds acceptable. Since then people may

<sup>6</sup><https://wordpress.org/plugins/p3-profiler/>

<sup>7</sup><https://jquery.com/>

have grown more impatient. But when considering these performance numbers you should consider that we ran an unlikely scenario where the web server with WordPress, the MySQL database and the (Chrome) browser with adaptation code were all running on the same (relatively slow) computer.

## 5. DEMONSTRATION SCENARIO AND FUTURE OUTLOOKS

In this demo we showcase an adaptive web-based application developed with a framework consisting on a CMS and an adaptation library. This application is aimed at supporting autistic students in higher education, but it is available to everyone. The application takes advantage of the use of learning styles and user history, but extra functionality can be added, such as notifications or a progress bar e. g. “you have studied only 5% of the material and there are only 2 days left before the exam”, etc. . . Extra adaptive features can include adaptive testing or selection of navigation tools - more independent students (with field-independent learning style) can be provided with a search option while less independent students (with field-dependent style) can be provided with a “Next” button that at each step will be bringing them to the most suitable material. While in the current version we support other media, like videos, those are yet scarce and we expect that content providers make more in the future. This will give us more adaptive capabilities.

It is important that concepts of privacy, information sharing and storage locations are communicated in a clear, non-technical and unambiguous way. Initial usability tests of the settings screen were carried with autistic students. Trial participants did not understand the control these settings offered them. Inadequately implemented privacy settings, are likely to increase anxiety rather than alleviate it for the students that participated in our trials. Therefore we need to find a way to improve the scrutability of our user profile.

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<sup>8</sup><http://www.handicap-studie.nl/>

<sup>9</sup><http://royhoutkamp.nl/>