NOVEL ADAPTIVE FEATURES OF THE AUTISM&UNI TOOLKIT FOR STUDENTS ON THE AUTISM SPECTRUM

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Abstract

Adaptation (or automatic personalization) is typically performed by a web server (extension). For reasons of performance and privacy it is a better idea to store sensitive user information on the client side and then also perform adaptation locally on the client. The WiBAF (Within Browser Adaptation Framework) has been incorporated into the AUTISM&UNI[1] toolkit in order to provide a personalized experience for students with some degree of autism, when they are transitioning from high school to the university. By considering autism as a combination of cognitive- or learning styles the developed framework can be used for other learning applications besides adaptation for students on the autism spectrum. WiBAF has been integrated with WordPress to enable non-technical authors to define adaptation while creating website content.

Keywords: autism spectrum, adaptation, privacy, learning styles

1 INTRODUCTION

Research on automatic personalization (or "adaptation") of information sources, mostly in an educational setting, has resulted in a number of platforms that consist of a webserver extension that performs *user modelling* and *adaptation* using server-side code and storage. There are several reasons why this server-side approach is not the best, including reasons of *performance* (all computation to be done on a server) and *privacy* (all user data is stored on and controlled by the server).

At the TU/e a research project was started, called WiBAF (Within-Browser Adaptation Framework), that has been adapted to form the technological basis for the Autism&Uni toolkit. WiBAF uses *browser-side storage* and *javascript* to perform the most privacy-sensitive tasks of user modelling and adaptation on the end-user's machine. With the strongest privacy setting nothing about the user is stored on the server side. For students with some degree of autism privacy is a major concern. With WiBAF they can receive personalized information without revealing their personal characteristics to the information server.

For the Autism&Uni project the adaptation has been incorporated in the popular WordPress content-management system to enable non-technical authors to create information once and have it be automatically adapted to each individual user. Two dimensions of adaptation have been realized in WiBAF for this purpose: adaptation to the *analytic vs. global* learning style dimension and adaptation to the *visual vs. verbal* learning style. Adaptation using other dimensions can still be added. We are currently considering adding also the *active vs. reflective* dimension. Students on the autism spectrum show strong preferences for information (presentation and navigation structure) in specific ways which are in fact forms of learning styles, and they would have more problems (than non-autistic students) if information is not provided in accordance to these preferences.

In the Autism&Uni project introductory information is being created for students entering the university for the first time. It includes scenarios for the different processes, administrative or physical, such as finding your way around the campus. For the *analytic vs. global* learning style dimension WiBAF adaptation code can either present the information in a piecemeal fashion, using a series of slides, or present the whole story for a scenario all at once. For the *visual vs. verbal* dimension WiBAF re-orders fragments, to either start or end with visual information such as a comic strip and/or a video. WiBAF can also be configured to leave out elements or to scale down visual information for verbal users. As an example of the combination of adaptation strategies, to present "directions" to a location on the campus we can (depending on the material available) provide the student with written directions (step by step for a verbal analytic user or a whole list at once for a verbal global user), a combination of

[1] http://www.autism-uni.org/

instructions with images (still step by step but for a visual analytic user), or by means of a map (for a visual global user).

When re-ordering information WiBAF can also take *prerequisites* into account. An author can indicate that certain steps or scenarios must precede others and the adaptation will then preserve that order.

The adaptation platform makes it possible to share the user model data with other applications, for instance with course material offered through WordPress. Whether the student wishes to share personal data with these other applications is kept under the user's control so as to satisfy also the more privacy-concerned students.

This paper is structured as follows: Section 2 introduces adaptive web-based educational methods and techniques, especially within the context of what is useful for students with autism. Section 3 describes how WiBAF and WordPress are combined in the Autism&Uni project and toolkit. Section 4 discusses future possibilities (beyond the scope of the Autism&Uni project) of applying WiBAF to support autistic students and concludes the paper.

2 ADAPTIVE EDUCATIONAL HYPERMEDIA AND ADAPTATION FOR AUTISM

Adaptive hypermedia [3, 6] has found applications in many areas but has been most popular in on-line education (also called e-learning or technology-enhanced learning). The basic idea behind using adaptive hypermedia is to give users some level of navigational freedom (the freedom to follow any of a number of links) while giving some advice or adapting content so as to ensure the user is guided towards information that can be understood (based on what the user visited before) and/or that fits with the user's interest (also based on what the user visited before). This is unlike a textbook where the author assumes the learner will go through it sequentially, from beginning to the end, without skipping parts.

Generally adaptation is based on a number of stable or dynamic "characteristics": properties of the user (personal data and perhaps personality traits), context (environment) such as location and time, and interaction history (leading to e.g. a model of the user's knowledge and interest). Our primary research interest in the past was on adaptation to dynamic characteristics such as the navigation history leading up to a user model of the user's knowledge in e-learning applications. The systems AHA! [4] and GALE [11] were created specifically for adaptation to information that can be derived from the individual user's browsing behaviour. They did also include the possibility to add and initialize more stable user properties in order to perform adaptation to characteristics such as cognitive or learning styles [12]. These systems were very generic: they allowed a technically savvy author to write arbitrary rules to derive user model information from the user's behaviour and to use that model for adapting content, presentation and navigation in any way desired (if supported by HTML and CSS). Both AHA! and GALE, like many other adaptation platforms, are built as a web server extension, using a database for the user models. As we explain below, for the Autism&Uni project we decided to use a newly developed platform: WiBAF, that performs the user modelling and adaptation on the client side.

2.1 Platform needs for students on the autism spectrum

Although there are many forms of autism, anxiety about the "unknown" is quite common. This leads to students with autism being more concerned about being tracked on-line than others, especially when they are not in control of their data and don't know what is being done with that information. Kobsa [7] already indicated that a lot of internet users are concerned about being tracked on the Internet. They don't mind and in fact find it useful (73%) that websites remember basic information like the users' name, and in fact are bothered (62%) if a website asks to enter information again that the user already provided earlier. The general population is most uncomfortable (91%) about being *tracked across multiple web sites*. The WiBAF platform we developed [8] stores all user-specific data in browser storage, on the end-user's computer. This still requires the user to have some trust in the server because the server provides the scripting code the browser uses to perform user modelling and adaptation and the server could potentially retrieve the model from the browser. But the browser-side storage technology protects the user's data against attempts by *other* servers to download it. This is an important reason why we chose to use WiBAF instead of previously existing well-established but server-side adaptation technologies.

Most popular online services offer some form of personalization or adaptation (think of recommendations on Facebook and YouTube and context-dependent search results in all major search engines). The *collective* behaviour of users (either of the whole population or of groups of similar users) is used

to optimize the adaptation. Because one user's behaviour is used to shape the adaptation for other users it may raise concerns that the individual user's data is not completely private. Although our earlier adaptive platforms (AHA! and GALE) explicitly exclude adaptation based on collective behaviour (and make user model data absolutely inaccessible by other users) the simple fact that the data is stored on a common server may already worry the most privacy-concerned users, including users with autism. Since WiBAF stores the user's personal data (aka user model) within the browser that data is guaranteed to be inaccessible for other users. The information server cannot use collective behaviour for adaptation. This should put autistic students at ease.

2.2 Adaptation needs for students on the autism spectrum

Adaptation for autistic students is first and foremost concerned with adapting to the differences in cognitive abilities, within this project in particular *comprehension*, between autistic and non-autistic people. Autism is often described as a "spectrum disorder" because the condition affects people in many different ways and to varying degrees.

In Figure 1 the bars represent behavioural characteristics of different forms or levels of autism and at the bottom of a "typical" person without autism as well.

The thin lines are the characteristics and the thick lines are emphatically present characteristics. The extent to which these characteristics occur differs in severity per person. As the figure shows people without autism do have traits of autism as well.

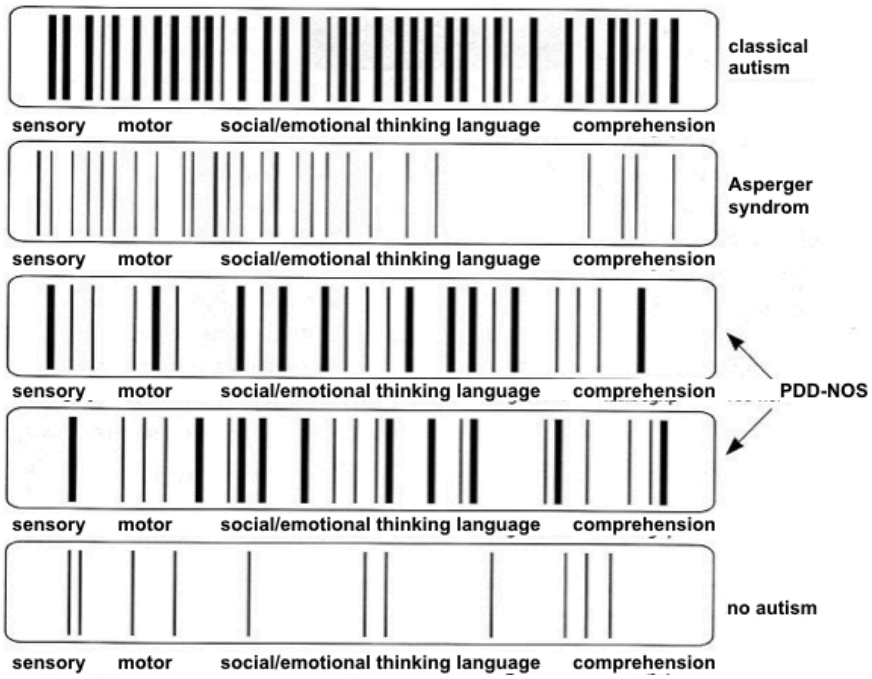

Figure 1. Behavioural characteristics of autism (translated from the work by de Bruin [2])

In the Autism&Uni project we mainly consider adults with Asperger syndrome [5]. As can be seen from Figure 1 they have fewer problems with speaking. Often people with Asperger syndrome are of average, or above average, intelligence. This is mostly a "hidden disability". With the right support and encouragement, people with Asperger syndrome can lead full and independent lives (and can be successful students at the university and in some cases even make it all the way up to professor).

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 like details but have difficulties “seeing the whole forest” [1]. Another comparison used by de Bruin [2] expresses this as: "autistic people see the world in loose puzzle pieces but have difficulties solving the whole puzzle and giving it a meaning". On the positive side this orientation towards details can make them strong in technical disciplines.

In our previous work [10] we discussed that it seems like autistic people have their own ways of processing and analysing information, their own ways of learning and as such they can be considered as having a specific *cognitive*- or *learning style*.

An adaptive tool can implement different strategies to support autistic students – to improve "underdeveloped" skills in establishing semantic relations, or in other words in building a big picture or to support strong qualities.

In the Autism&Uni project an (adaptive) information source is being created to help students transition from high school to the university. This information is to be available for all students. To cater for the specific needs of autistic students we consider adaptation to the following learning style dimensions (descriptions taken from our previous work [10]):

- *global vs. analytic*: Global students are concerned with the whole meaning and the end goal or results. They require to first see an overview of the "big picture" before they deal with details. Analytic students on the other hand prefer to learn one detail at a time in a meaningful sequence. Once they know all the parts, they put these parts together and comprehend the "big picture". Autistic students are more likely to be analytic in their preferred approach. (Despite that some will never see the big picture and remain stuck with a series of details, but that series does lead to the end goal or result.)
- *verbal vs. visual*: There is actually a larger collection of styles that includes *auditory*, *tactile* and *kinesthetic*, but because we are dealing mostly with websites displaying information the division between the *verbal* preference for text or *visual* preference for images and perhaps animations or video is most useful in our context. Autistic students can be verbal or visual, but perhaps with a stronger preference than is found in non-autistic students, making the adaptation to this dimension more important.
- *active vs reflective*: These are also two from a larger collection (including *pragmatist* and *theorist*). An *active* user likes to do something with new information in order to understand it, and is thus aimed at immediate experience and experimentation. Active users generally like group work because this enables them to do active things. Reflective users like to gather information and "mull things over". They think about new information before acting on it. As a result they also prefer to think problems through *on their own* rather than discussing them in groups. Autistic users are obviously more reflective than active. In the Autism&Uni toolkit we do not yet have adaptation for this dimension but generally cater more for the reflective than the active user.

The combination of the two dimensions we consider lead to adaptation of the information type (more text versus more images) and of the presentation and navigation: showing an overview with accessible details versus a "slideshow" (sequence) of steps.

3 WIBAF AND THE AUTISM&UNI TOOLKIT

WiBAF is a JavaScript library, i.e. a set of pre-defined pieces of code that are executed on the client's computer. Its purpose is to allow web developers to easily add adaptation to a webpage in a way that users' privacy is taken into account. WiBAF applications are written using code that is similar to CSS [9]. Although WiBAF executes code and stores data on the client's computer, it avoids placing any burden on the users, like installing software. The only thing the user needs is a web browser capable of executing JavaScript. All modern browsers include support for storing data inside the browser itself, which allows JavaScript code to store and retrieve data on the client, in a way that is persistent, i.e. survives between browsing sessions.

The WiBAF philosophy is not only to execute and store user data on the client's computer, this is only its default behaviour. WiBAF also gives the users the opportunity of making decisions about their personal data. WiBAF allows users to release their personal data to the server in exchange for something else. In Section 3.2 we will explain what users can get in exchange of their personal data in the specific case of the Autism&Uni project.

WiBAF has been used in the Autism&Uni toolkit in order to fulfil the privacy and adaptation needs described in Sections 2.1 and 2.2. To do so, we needed to integrate WiBAF with a content management system, to make it easy for the experts in autism to upload the content and to have adaptation code added to it automatically. We will now introduce which specific adaptation tasks are performed and how we needed to adapt WordPress to suit our needs.

3.1 Specific adaptation tasks

In order to tackle specific adaptation needs, WiBAF performs several strategies. Firstly it re-orders the content presented on a post (the Wordpress term for a page or article) according to the user preferences in two dimensions: how verbal (versus visual) the user is and how active (versus reflective) the user is. Each post is divided in different sections and some users have a preference for some of those sections over others, therefore we promote the most interesting pieces of information and move to the bottom of the page those that are not (or less) interesting for a specific user.

We also consider how the information should be presented to each type of user. Therefore we provide two ways of visualizing the same content and in the same order. We have developed two views: a page view and a slide view. In the page view, all the information (in an article) is presented in a single page, while with the slide view, the different sections are presented each on a single page.

Moreover, we have information about several topics, and this could grow even more, so we need to structure the information (and navigation) somehow. At the same time we want to give some flexibility, therefore we added some prerequisites to the articles. This is done in order to indicate that some information should be read in a specific order, and in case this is not done, we can present an easier version of the more advanced content. (Brusilovsky [3] calls this a *prerequisite explanation*.)

In order to track the user preferences in the Autism&Uni project, and being able to personalize the content offered through our platform, we have made the following assumptions:

1. If the learning object contains videos, and the user watches them, then she is more visual and therefore we should promote the videos and other graphical content. In the case the user ignores the videos, then we should show them at the bottom of the page or even hide them completely (and assume the user is more verbal). If the learning object does not have any graphical content, the user profile will remain as it is, regarding the visual vs. verbal dimension.
2. If the user chooses to see learning objects in the slide view, then she likes the slide view, otherwise she prefers the page view. The next learning objects that she visits, will be shown in the way that she prefers.
3. If the user explicitly defines herself as active instead of reflective, we will show the content in which the user has to take the initiative at the top of the page, otherwise we will show it at the bottom. This adaptation dimension is not currently used in the Autism&Uni Toolkit.

For all the variables, the user can explicitly select a value to adjust the user tracking. This will be explained more in depth in Section 3.2.

3.2 Integration of WiBAF with WordPress

In order to integrate WiBAF with WordPress, we made some adjustments to the normal WordPress installation, together with a base style to use in the toolkits of every project partner. First we need to tag every section, so that WiBAF can recognise it and move it or hide it when needed. This seems trivial when we only have static content, but we need to always do it in a way that new content is automatically tagged when it is added. We use a plugin called “Advanced Custom Fields”, so that each section has its own text box in the administrator dashboard. This way the system knows which portions of text correspond to which logical sections and those can be re-ordered, hidden or shown depending on the specific user preferences. We also used the same plugin in order to add repeater fields that can be used to specify one or more prerequisites for each learning object. Our custom WordPress form for editing a post can be seen in Figure 2. Several fields have to be completed in order to compose a learning object. These fields are converted into fragments that WiBAF can manipulate, hide or re-order according to the user needs. The number and type of fields that are displayed depend on the category of the learning object, which can be selected in the right boxes. (In a standard WordPress installation there would only be a single title field and a text editor field for the page content.)

In order to keep track of which pages the user reads, we need to modify the WiBAF adaptation code whenever a new learning object is created. This has been be automated as well by writing some custom code in our WordPress installation. This code is triggered every time a new learning object is created and it updates the WiBAF adaptation code.

Finally, in case the user opts to store her information on the servers, we also need to provide support for this functionality. To do so, we used custom user fields, which are stored in the database together

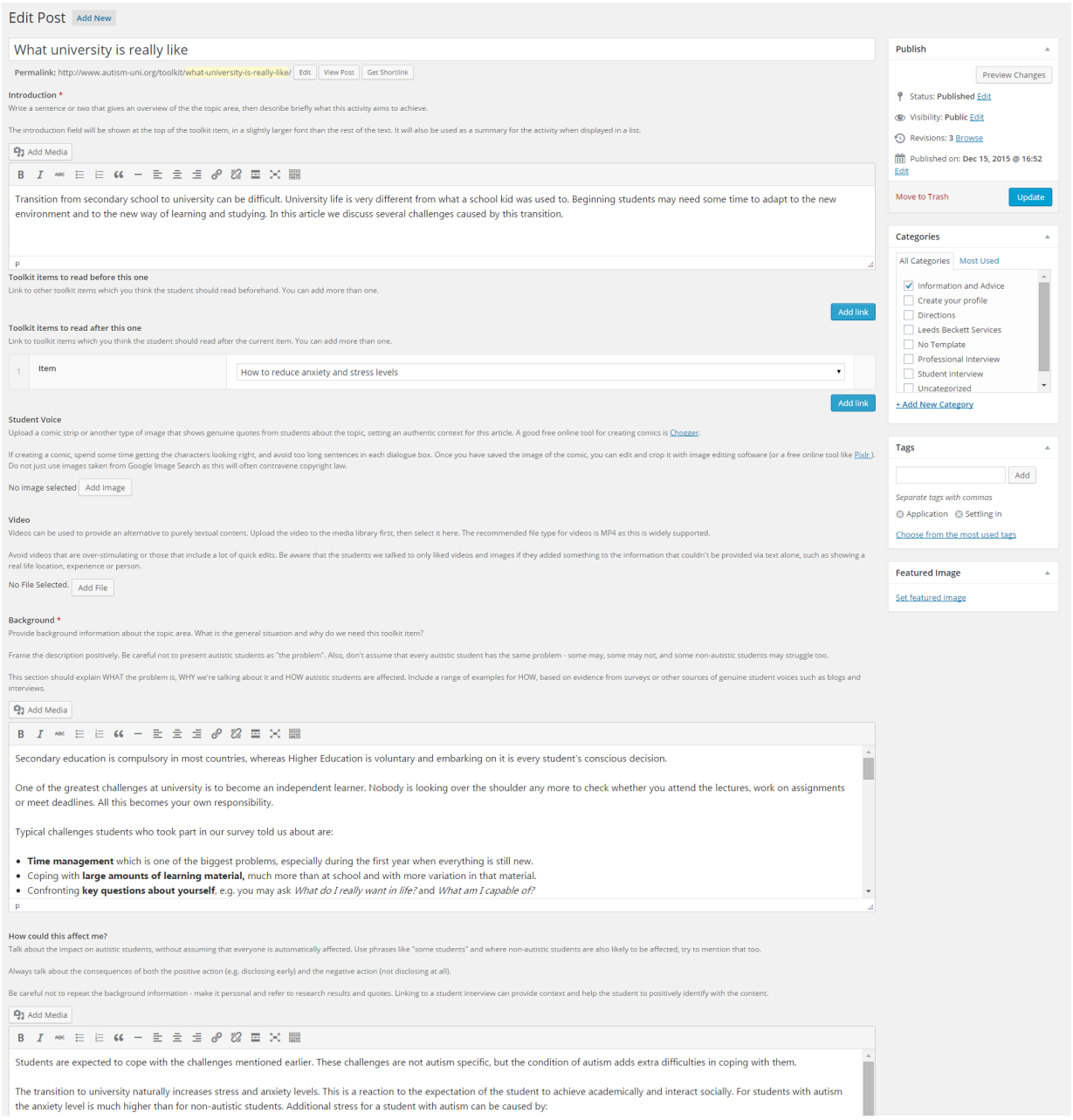

Figure 2. Our custom WordPress form to add/edit a post

with other user information. This way the user could synchronise her profile across different devices, or get more advanced recommendations based on the aggregation of different profiles. Providing these advanced recommendations is still future work. Server-side user modelling of course comes at the cost of losing privacy. In fact, there is a trade-off between more privacy versus better personalization. WiBAF offers the user the possibility to "pay" (with personal data) the price of being able to synchronize her profile or get more personalization. In this specific case, we define four different levels for the user to choose from:

1. In the first level, no data is tracked and therefore there is no personalization, the result is that there is no personalization for the specific user.
2. In the second level, the default one, the user data is tracked and stored on the user's computer. Therefore the user still has all the privacy and some personalization available.
3. In the third level, the information inferred from the user behaviour (in this case, the learning styles) is kept private in the user's computer, however, other information like the browsing history is sent to the server, so that the user can switch to a different browsing device and continue where she left off.

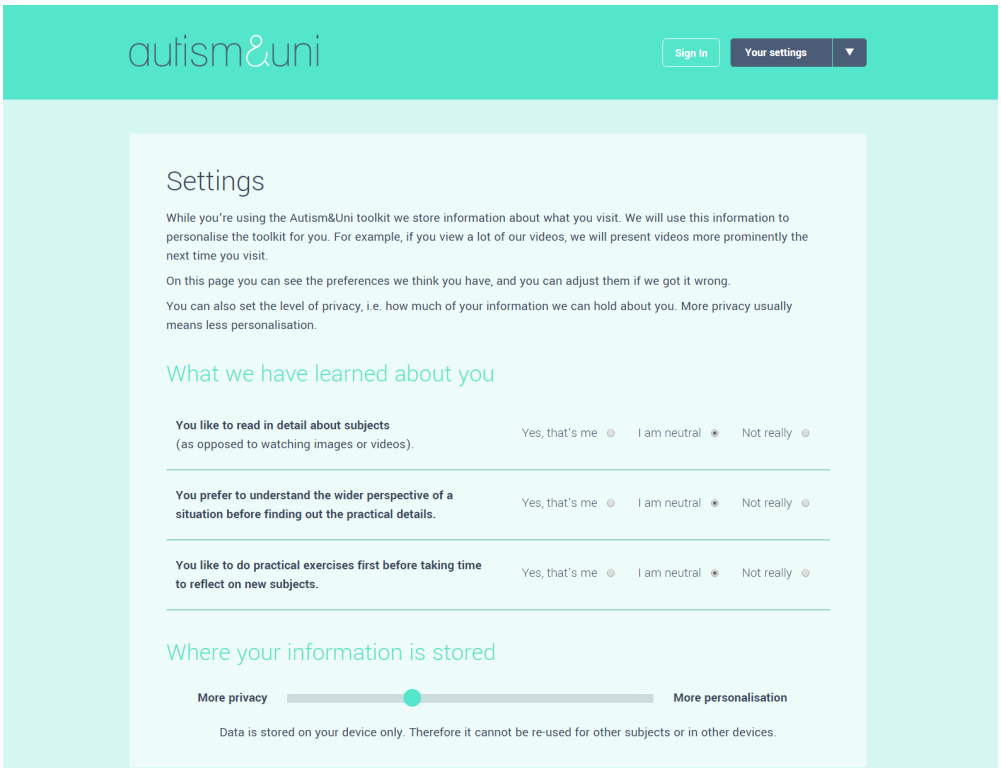

Figure 3 Settings page

4. In the fourth and last level, all the user´s information is sent to the server. This implies that the user will see the same information and present it in the same way on all her devices, but this also means that the server has access to all her information.

Once we installed and configured everything, and together with a graphic designer, we created a custom WordPress theme for the Autism&Uni project. We are not going to discuss the graphical aspects, as this is not the aim of this paper, but we describe the changes made to make it work with WiBAF.

First, the most obvious thing is to add WiBAF to all the pages. In WordPress all the pages have a common header and footer which can be modified by changing a single file. We took advantage of this to add the code to insert WiBAF in the footer file. In a similar way, we also linked the adaptation and modelling files in which we then inserted the code to perform all the adaptation and user modelling.

After that, we also needed to modify the templates created for the different categories, so that each fragment is properly tagged. Once each fragment can be recognised as a unique HTML element, WiBAF can manipulate it.

Finally we needed to implement the user controls to modify, eliminate or correct their data, and also to select where it is stored. Some functionality can be done within a learning object (e.g. changing the way of visualizing it), but this is done mainly in a settings page in which the user can position herself in the three learning style dimensions described in Section 2.2 using the buttons shown in Figure 3. The user can also choose her preferences about the storage of the data by means of the slider shown in the same figure.

4 DISCUSSION

Organizations specialising in autism and helping universities and colleges (e.g. Handicap+Studie in the Netherlands[2]) suggest responding to the diversity of the students. They aim at inclusive higher education in which as many different students as possible can participate in and which is universally adaptable for people with different needs. There is no "standard" student. Everyone is different. Everyone has their own talents including students with disabilities. Universities should let them focus on their talents and use them as much as possible without being hampered by any disability they may have.

[2] http://www.handicap-studie.nl

Handicap+Studie strives to offering alternative (flexible) learning routes – the idea behind Universal Design for Learning (UDL, see for instance https://www.youtube.com/watch?v=c9WHNBNlmVo). Students with different learning styles, talents and possible disabilities can then follow the learning path that suits best and get the most out of their education. Several colleges and universities in the Netherlands already apply this idea[3], offering variety in lessons, using different forms of blended learning and different representations of learning material (e.g. visual/audio versus verbal)

At TU/e students on the autism spectrum are guided by student psychologists towards becoming fully independent. Such guidance/supervision is very intensive in the beginning but gradually decreases. This guidance is fully customised to each individual student. As such it is becoming prohibitively expensive when student numbers keep growing as they are.

Our adaptive tool can potentially allow for the inclusion of the same strategy – to offer a lot of adaptation in the beginning and in case of good progress of the student slowly start switching to less adaptation.

As we have approached adaptation to autism as a form of adaptation to learning styles the technology we developed offers the possibility for adaptation not only to autism in general and to the variations of autism but also to differences in learning preferences of students not diagnosed with any form or level of autism.

There is a lot of potential in using our adaptive tool to support the transition from high school to university as well as the study process at the university. Yet the already implemented strategies first have to be evaluated within the Autism&Uni project.

5 ACKNOWLEDGEMENT

The research leading up to this paper has been made possible thanks to the AUTHEW (Autism&Uni) project, part of the Erasmus Life Long Learning Programme. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use, which may be made of the information contained therein. The WiBAF technology has been developed as part of the "Impuls" research program of TU/e. We would also like to thank TU/e psychologists specializing in autism, TU/e students with autism who participated in interviews with us, Stichting Handicap+Studie and Autastic[4] for their valuable input.

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