WiBAF into a CMS: Personalization in Learning Environments Made Easy

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ABSTRACT

Adaptivity has proven successful in reducing navigation and comprehension problems in hypermedia documents. Authoring of *adaptive hypermedia* documents and especially of the *adaptivity* in these documents has been problematic or at least labour intensive throughout AH history. This paper shows how the integration of a CMS with an adaptive framework greatly simplifies the inclusion of personalization in existing educational applications. It does this within the context of European project Autism&Uni that uses adaptive hypermedia to offer information for students transitioning from high school to university, especially to cater for students on the autism spectrum as well as for non-autistic students. The use of our *Within Browser* adaptation framework (WiBAF) reduces *privacy* concerns because the user model is stored on the end-user's machine, and eliminates *performance* issues that currently prevent the adoption of adaptivity in MOOC platforms by having the adaptation performed on the end-user's machine as well (within the browser).

Authoring of adaptive applications within the educational domain with the system proposed was tried out with first year students from the Design-Based Learning Hypermedia course at the Eindhoven University of Technology (TU/e) to gather feedback on the problems they faced with the platform.

CCS Concepts

•Information systems → Web applications; •Software and its engineering → Software creation and management;

Keywords

adaptation, learning styles, content management systems, software development

1. INTRODUCTION

Adaptive hypermedia has been successful for many years in improving the ease of navigation and the user comprehension of the content on Hypermedia documents [3, 5, 7]. However, adaptive hypermedia needs more effort from the development/authoring team than hypermedia applications without adaptive features [4]. While this is sometimes seen as a burden, the effort that would be needed to have equally good navigation and content and comprehension properties in a non-adaptive hyperdocument would be far greater. The scientific community has been trying to minimize the extra development and authoring effort for years by using custom-made languages [11, 13, 20] or graphical interfaces [19]. Even without considering adaptation, relatively few people can develop HTML applications directly through writing in HTML syntax and even fewer people can add adaptive behaviour to them.

Content Management Systems (CMSs hereinafter), have become very popular tools for the development and maintenance of web applications, mainly because they enable people without any knowledge of HTML, CSS or other (client- or server-side) web languages to design professional looking websites. Some of these CMSs are free and open source, allowing people to develop all kinds of plugins or modify the core of the CMS to extend its functionality. According to a survey made by the website http://w3techs.com/, as of April 5$^{\text{th}}$, 2016, 44.4% of the web pages that they track run one of no less than 313 CMSs that they monitor. Among those WordPress[1] is the most popular one, present in 26.3% of all the sites tracked.

CMSs have helped many people to build their own website without in-depth knowledge of web technologies, yet there are no CMSs that take effective advantage of adaptive hypermedia extensions. Existing Adaptive Hypermedia Systems may try to make the creation of adaptive websites feasible, but no current AHS achieves the user-friendliness of popular CMSs. Hence we turn the process around: from *creating adaptive websites*, we move to *making websites adaptive*. To do so an existing CMS needs to be extended with adaptive functionality. This paper describes such an extension: integrating adaptive functionality in WordPress. It also describes the use of this functionality in the European Autism&Uni project[2] to adapt information to students on the autism spectrum, specifically for helping them with the transition from high school to university. The adaptive functionality we used is more generic, allowing for adaptation to different learning styles and to general "prerequisite" relationships between topics. The WiBAF (Within-Browser Adaptation Framework) extension to WordPress also takes care of typical privacy concerns of users by performing user modelling and adaptation entirely within the browser (and thus on the end-user's device rather than on a server).

In order to develop our work we have taken the following decisions:

- We used WordPress as our CMS because it is free, open-source and the most used in real-life environments.

[1] see https://wordpress.org/

[2] see http://www.autism-uni.org/

- We used WiBAF [12] as our adaptation library because the client and server code are decoupled and it is easy to modify the server code to make it compatible with WordPress. (WiBAF is not limited to be used with WordPress and has been also used to add adaptation to websites created with different CMSs, or without any CMS.)

- We focused on an on-line educational setting. In order to perform adaptation in such setting, we focused on *how* the student learns, *what* the student has already learned and what is still to come.

With these decisions taken, our goal became to integrate WiBAF and WordPress in such a way that personalization can be easily added to existing educational sites created using WordPress. At the same time the adaptation should be done efficiently and it should track how the user learns and what she has already learned. The efficiency needed for massive applications like MOOCs (Massive Open Online Courses) can actually easily be obtained because almost all of the work is done in the browser, thus avoiding server-side performance bottlenecks.

Therefore, our contribution with this paper is the integration of an adaptation library in a Content Management System in order to ease the development of adaptive educational applications. This can be applied to current existing applications like MOOCs in an easy way. This means that rather than developing applications from scratch, our tool allows to make existing applications adaptive.

The remainder of this paper is structured as follows: We describe our use case scenario in Section 2 and then we describe how the integration between WiBAF and WordPress has been made in Section 3. Section 4 explains how to develop adaptive educational applications, both for existing applications and new ones. Later, in Section 5, we describe the experiences of first year students with the tool. The related work is presented at Section 6. Finally, we conclude and propose future work in Section 7.

2. USE CASE SCENARIO

Before describing how the integration has been done, we introduce our use case scenario to make the requirements we have come up with more concrete. It is worth mentioning here that the platform developed is generic and as such can be applied in different domains. Recently we have used it in the educational context in our first year course Design-Based Learning Hypermedia, in particular for creating the “First Aid Kit” for students entering the university.

We set forth to use the WordPress and WiBAF integration in the Autism&Uni project. This project 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[3] is offered as an Adaptive Web-Based Application.

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.

Adaptation for autistic students is concerned with adapting to the differences in cognitive abilities, within this project in particular comprehension, between autistic and non-autistic people. In our previous work [14] we discussed that it seems like autistic people have their own ways of processing and analysing information, their own ways of processing, analysing information and learning and as such they can be considered as having a specific cognitive- or learning style. In order to provide effective adaptation, we utilize the specific characteristics and preferences of the user in three different learning styles dimensions [10], 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 [8].

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. 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).

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.

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 on how 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.

In order to effectively display the content of 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 article 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. INTEGRATION OF WIBAF AND WORDPRESS

In order for WiBAF to understand the content of a learning object, the “sections” of a page need to have a unique identifier within that page. WordPress allows developers to create custom themes to change the look and feel and the structure of a page. We used this functionality and created a custom template that creates the sections and assigns `ids` that WiBAF can understand.

In order to make content providers aware of this division, we needed to modify not only the page template itself, but also the interface used to enter page content. We used a plug-in called Advanced Custom Fields[4] or ACF for that.

WordPress also allows developers to create plugins in order to extend its functionality. We have packed all the functionality required for WiBAF in a plugin. We will describe now the functionality present in our plugin. (This knowledge is not needed to

[3] http://www.autism-uni.org/toolkit/

[4] http://www.advancedcustomfields.com/

understand the authoring process.)

WordPress offers a settings interface that has been modified to add new fields related to the user model. The data contained in those fields are stored in the client by default. WiBAF offers users the possibility to send these data to the server if desired. That could make it possible to (potentially) create better personalization (through collaborative filtering) or to provide a facility to synchronize their data between devices. By default the data are stored on the browser only, to offer better privacy. We also needed to add these new fields to the user data so that they can be stored on the server (if desired). The management of the database is done automatically by WordPress, we just need to declare that these extra data exist. The communication between server and client to manage user data is done as follows: when (and if) the user wants to send data to the server, this is done through cookies. These cookies are created using JavaScript after the page is loaded and WiBAF has finished parsing and executing the modelling and adaptation files. Therefore, the cookies will contain the user values after visiting the page, but every interaction that the user might do that can change the user model, will not be sent in this cookie, but in the following one, after another request. When the server wants to update the client values (e. g. the user logs-in from a new device and she wants to keep her profile), it inserts the JavaScript code required to do so. This code is inserted just after the cookie creation and updates its values. This might not seem efficient, but because the values are stored asynchronously in the IndexedDB, it is more efficient to create the cookies and then update them when the database has finished the insertion operations.

The content of a website offered through a CMS is very dynamic because it is very easy to create and update. Therefore, we need to replicate this dynamism in our adaptation code. To do so, we have to update the adaptation automatically when a new learning object is created. We achieve this by using *action hooks*. The action hooks provided by WordPress are not only related to special actions. In every page request, typically around 50 actions are executed. Code can be hooked to a specific action. This code will then be executed when that action occurs. In our plugin we hooked code to several actions to link the WiBAF JavaScript library, the adaptation files, and to store user data in the browser (or on the server if the user wants that). It is worth mentioning that we also "taught" WordPress to write adaptation code for us. Every time a new learning object is created, WordPress writes some lines of adaptation code to track it.

4. DEVELOPMENT OF ADAPTIVE APPLICATIONS

As we mentioned before, the integration of WiBAF and WordPress was built so that creation of adaptive applications from scratch is possible, but also adding adaptive behaviour to an existing application is possible. This means that the tool is useful for creating adaptive applications, but also for making existing applications adaptive. While the tool is generic, our implementation was built having in mind the educational domain, therefore in the following subsections we will explain how to create new adaptive applications in the educational domain and how to make an existing educational application adaptive.

4.1 Creating new adaptive applications

In order to create an adaptive application from scratch in our WordPress, the workflow is quite similar to the process of creating a normal WordPress application as described in the official tutorial[5]. However, because we have divided our content in small fragments

[5]https://make.wordpress.org/support/user-manual/content/

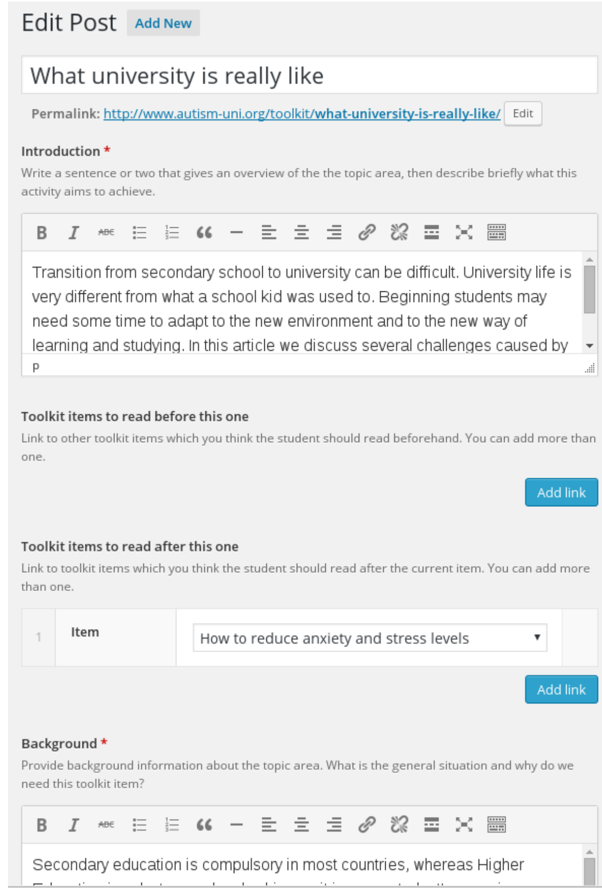

Figure 1: Custom fields as shown on the dashboard.

(sections), this needs to be considered both in the template and in the dashboard. As we mentioned before, we used the ACF plugin to achieve this in the dashboard and we modified the post template in our theme so that it is consistent with the ACF settings. Figure 1 shows the view from the dashboard of the fields; as it can be seen each field should be filled according to the instructions in order to create a learning object.

Once the learning objects are created, the authors can proceed to add the adaptive behaviour to the existing application, as described in the next subsection.

4.2 Adding adaptive behaviour to an existing application

In order to add adaptive behaviour to an existing application, WiBAF can be added as a WordPress plugin. This can be done as shown in the official WordPress tutorial[6].

Once the plugin is installed, WiBAF can be configured from the dashboard as shown in Figure 2. The privacy levels can be configured, as well as the path where the adaptation and modelling files are located. These files follow the format described in our previous work [13].

The adaptation and modelling files can be modified in order to fit other needs, but the files we provide automatically track the user learning styles as we defined in our requisites, as well as her user history and it can react to it by hiding the unsatisfied pre-requisites, or by re-ordering fragments of the learning object.

[6]https://codex.wordpress.org/Managing_Plugins

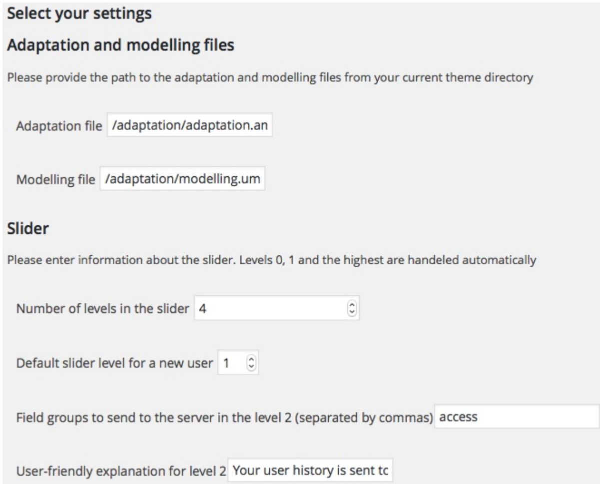

Figure 2: WiBAF settings.

WiBAF also offers users control over where its user model is stored. This is done by using a slider with three or more levels. In the first level of the slider, no data are tracked and therefore no personalization is offered. In the second level, all the data is stored on the browser. In the last level, all the data is stored on the server. The WiBAF plugin makes it easy to add new levels between the second and the last, in a way that only certain types of fields are sent to the server, while others are kept private in the browser, always depending on the user preferences.

5. EVALUATION WITH STUDENTS

Our first year students from Design-Based Learning Hypermedia course have used a preliminary version of the WiBAF and WordPress integration in order to develop adaptive educational applications. The most substantial difference between the version that the students used and the one described here is that WiBAF was not offered as a plugin, but its code was closely tied to the WordPress theme used (by the Autism&Uni project). It is worth mentioning that while some of the students that took the course had learnt some programming by themselves, most of them did not develop any web application before, not to mention an adaptive educational web application. After finishing the course, we invited them to complete a survey about their experiences with the tool. In total, 36 students completed the survey. They made it obvious that a plugin needed to be created, because the most difficult task for them was to extract the changes that made WordPress adaptive from the Autism&Uni theme and incorporate them into their own theme. 69% of the students found this task "hard" or "very hard". Figure 3 shows the distribution of the opinions of the students regarding this task. With a plugin, this should become easier. Once the students managed to have the whole environment setup, and the WordPress customized as they wanted, the percentage of students that found adding adaptation "hard" or "very hard" was reduced from 69% to 22%, with 28% of the students finding it "easy" or "very easy" while the rest judged the difficulty of developing an adaptive educational application as neither hard nor easy. This can be seen in Figure 4. A similar result was obtained in another similar evaluation of GALE [6], in which the installation aspects were considered harder than the development of applications itself.

We also asked students to estimate the extra time that they had to spend in order to make the application adaptive, as compared to the

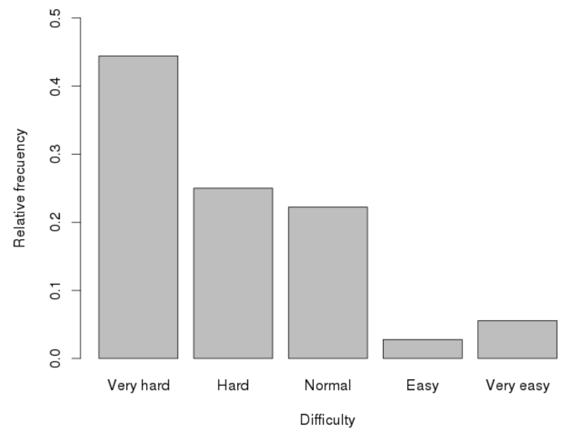

Figure 3: Difficulty to integrate the adaptation into the WordPress according to the students.

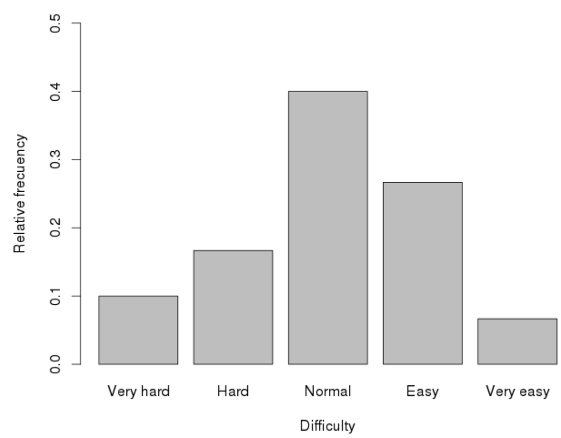

Figure 4: Difficulty to develop an adaptive educational web adaptation with our tool according to the students.

development of a normal application. 48% of them thought that enabling personalization in an educational application takes 20% more time than a non-adaptive educational application while 69% of them estimated that the overhead introduced during the development was of about 50% or less. We think that these numbers will be improved even further, because as we mentioned before, the harder task has been greatly simplified. However, these numbers may not be very significant because the first year students had never before seriously considered adaptation, so more "serious" adaptation authoring may take more work because it requires more careful design by the authors.

6. RELATED WORK

Adaptive Hypermedia is a research field that can be traced back to the nineties [2]. It has become more complex since then and several frameworks have been developed. They aim to ease the development of this kind of applications. Some good examples of those frameworks are AHA! [9] or GALE [17]. The work presented here takes an approach more similar to InterBook [4] in the sense that authoring is done using a standard tool (that was Microsoft Word for InterBook) and adding the "hints" for adaptation based on the student's knowledge and on prerequisites was only a small extra effort. We also take into account student knowledge by checking the browsing history, but we extend that with adaptation to cognitive/learning styles and further we combine it with the simplicity of CMSs. We also provide tools to give control to the users about where their data is stored, either in the client or in the server, with all its advantages and disadvantages. Another authoring tool related to our work is the Dynamic Courseware Generator [21], which allows to create courses that adapt to the student knowledge. It also allows students to define their own learning goals and the tool will recommend a path to follow. One more research effort worth mentioning here is ALEF [16]. ALEF divides each learning object into fragments and uses strategies to re-order content; it also supports different types of learning objects such as explanations, questions and exercises and adds metadata to the content to produce the resources that are consumed by the students. However, it does not deal with the authoring of the adaptation itself.

Cognitive/learning styles refer to the different ways a person processes, analyses information and learns. There is previous research on adaptation to cognitive/learning styles and how these can be incorporated into Adaptive Hypermedia Systems and e-learning platforms [15, 18]. While adaptation to learning styles is useful in every e-learning platform, this is especially important in our use case scenario with autistic students as we showed in our previous work [8, 14].

To the best of our knowledge, little work has been done about bridging Content Management Systems and Adaptive Hypermedia, at least when considering Adaptive Hypermedia to be a broader concept than responsive design (which is adaptive only to the user's browsing platform). The only work similar to what we have built was done by a master student in Eindhoven: Sander Brouwer [1]. In his work, a CMS with built-in adaptive characteristics was developed from scratch. This makes it more efficient than our approach, but it is unlikely that real life production environments would adopt a new CMS that does not have a big community solving issues or developing plugins, like WordPress or Joomla[7]. This work also required authors to write the adaptation rules themselves while in our work, the framework that we developed is already adaptive to the user history and learning styles and has a straightforward usage in the educational domain.

An important new development in learning is the publicly available MOOCs. The *massive* nature of MOOCs requires high performance platforms for serving content, perhaps even using server-side page caching (to eliminate most of the page regeneration time). Most common adaptation platforms require that the adaptation is performed on the server side, resulting in different page content for each user, and different presentation of links on the pages. By using WiBAF the user modelling and adaptation effort can all be performed inside the end-user's browser, thereby significantly lowering the computation to be done on the server side. As a result the approach taken by WiBAF is the only feasible solution for adding adaptation to MOOCs. There may be (still unreported) ongoing work on adaptation for MOOCs but no on-line courses that are really massive are currently adaptive.

7. CONCLUSIONS AND FUTURE WORK

In this work we have shown how personalization can be enabled in existing Content Management Systems in order to ease the development of Adaptive Web Based applications in the educational domain. We have limited our research to the adaptation in e-learning environments, but this could be extended to different domains. We automatically track the user knowledge via her browsing history as well as user learning styles, looking at what users do with the content provided. Then we adapt the content using those user features. By integrating WiBAF into WordPress, we also allow developers to make existing applications adaptive, besides making adaptive applications, thus allowing content providers in focusing on the content rather than in the adaptation.

We tried our framework in the use case scenario for the Autism&Uni project and in the first year Design-Based Learning Hypermedia course at TU/e for creating the "First Aid Kit" for students entering the university. After following the course the students were asked to provide us with some feedback about their experience with the framework. This feedback has been taken into account to greatly ease the most difficult task pointed by the students.

Our framework allows for the development of adaptive applications by using learning styles and user history, but extra functionality can be supported as long as they are generic for educational applications. This functionality should be added to the plugin code. Non-generic functionality can also be implemented by editing the adaptation and modelling files used in WiBAF.

8. ACKNOWLEDGMENTS

This research is supported by the project WiBAF and the Lifelong Learning Programme (project no. 10018300 Authew 539031-LLP-2013-1-UK). This publication reflects the views only of the authors, and the Commission cannot be held responsible for any user, which may be made of the information contained therein. The authors thank the Autism&Uni project team, TU/e psychologists specialising in autism, TU/e students with autism who participated in interviews with us and toolkit evaluation, Stichting Handicap+Studie[8] and Autastic![9] for their valuable input.

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