Creating a Personalized Artificial Intelligence Course: WELSA Case Study

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ABSTRACT

This paper illustrates the use of WELSA adaptive educational system for the implementation of an Artificial Intelligence (AI) course which is individualized to the learning style of each student. Several of the issues addressed throughout this paper are describing similar approaches existing in literature, how the AI course is created, and what kind of personalization is provided in the course including the underlying adaptation mechanism. The authors also focus on whether the course is used effectively by the stakeholders (teachers and students respectively). Results obtained in the paper confirm the practical applicability of WELSA and its potential for meeting the personalization needs and expectations of the digital native students.

Keywords: *Adaptive Educational Systems, Computer Science Education, Course Implementation, Individualized Instruction, Learning Resources, Learning Styles, Web-Based Education*

INTRODUCTION

The advent and omnipresence of information systems have been revolutionizing and changing not only the way we communicate access information and conduct businesses, but also the way we learn. In the world of pervasive Internet, learners are also evolving: the so-called "digital natives" want to be in constant communication with their peers, they expect an individualized instruction and a personalized learning environment. In this context, we present such an adaptive educational system, called WELSA, illustrating it with a course module on "Artificial Intelligence". According to Brusilovsky and Millan (2007), adaptation can be done with respect to various factors, such as knowledge, interests, goals, background, individual traits and context of work. In this paper we base our adaptation on one of the students' individual traits, namely their learning style (i.e., a specific manner of approaching a learning task, the preferred learning strategies activated in order to fulfill that task).

Motivation

Our endeavor was motivated by several aspects.

First, many educational psychologists support the use of learning styles, claiming that they have an important effect on the learning process (Popescu, 2010a); however this is not

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to say that the domain is free from controversies (Coffield et al., 2004).

Secondly, during the past several years, quite a few researchers dedicated their time to the development of learning style based adaptive educational systems (LSAES), as we will see in the next section. Most of them reported positive experimental results with their systems, finding improvements in student learning gain and/or satisfaction (Bajraktarevic et al., 2003; Carver et al., 1999; Graf et al., 2009; Lee et al., 2005; Limongelli et al., 2009; Papanikolaou et al., 2003; Sangineto et al., 2008; Triantafillou et al., 2004; Wang et al., 2008). Once again, contrary results have also been reported, with (Brown et al., 2009) being a representative study in this respect.

Thirdly, due to the huge expansion of the Web, the amount of information made available in current e-learning systems is very large, definitely larger than what could be presented by traditional teaching means. While being a positive aspect, this availability can also have a downside - it could easily become overwhelming for the students. It is therefore of a particular importance to filter the content in order to avoid cognitive overload of the learners. Furthermore, it is important to decide how to best present this content and in what sequence (the navigation type).

WELSA Overview

The e-learning platform used in our study is called WELSA (**W**eb-based **E**ducational system with **L**earning **S**tyle **A**daptation). More details about the system and the principles behind it can be found in (Popescu et al., 2009). Basically, WELSA's main pedagogical goal is to provide an educational experience that best suits the learning preferences of each student, in terms of perception modality, way of processing and organizing information, as well as motivational and social aspects. All these preferences are condensed in a so-called Unified Learning Style Model (ULSM). A detailed description of the ULSM components, together with its rationale and its advantages in Web-based learning settings over traditional learning style models are provided in (Popescu, 2010a).

WELSA is composed of three main modules:

- An authoring tool for the teachers, allowing them to create courses conforming to the internal WELSA format (XML-based representation).
- A data analysis tool, which is responsible for interpreting the behavior of the students and consequently building and updating the learner model, as well as providing various aggregated information about the learners.
- A course player (basic learning management system) for the students, enhanced with two special capabilities: i) learner tracking functionality (monitoring the student interaction with the system); ii) adaptation functionality (incorporating adaptation logic and offering individualized course pages).

The rest of the paper is structured as follows: the next section includes a review of other courses deployed using related LSAES (i.e., courses adapted to students' learning styles). The following two sections present an AI course (inspired from (Poole et al., 1998) classical textbook) deployed in WELSA; first the system is seen through the eyes of the teacher, who also plays the role of course author; next the system is seen through the eyes of the student, who has to learn the adapted course. Subsequently, both the authoring and the adaptation approaches are validated by means of experimental studies. The last section contains some conclusions and future research directions.

RELATED WORKS

In what follows we will give an overview of similar works reporting on the implementation of personalized courses with respect to learning styles; the adaptation techniques used are presented, together with evaluation data where available. A summary of the reviewed papers is included in Table 1.

- Carver et al. (1999) devised a hypermedia course on "Computer Systems", individualized for 3 dimensions of the Felder-Silverman model (FSLSM) (Felder & Silverman, 1988): sensing/intuitive, visual/verbal, sequential/global.

The course includes a large variety of multimedia educational resources: hypertext, audio files, graphic files, digital movies, instructor slideshows, lesson objectives, note-taking guides, a virtual computer simulation tool, quizzes in a 3D gaming engine etc. For each category of resources, the teacher has to mention its suitability (support) for each learning style (by rating it on a scale from 0 to 100). When a student logs into the course, a CGI executable loads the student profile (i.e., his/her learning style as resulted from answering a dedicated questionnaire); it then computes a unique ranking of each category of resources, by combining the information in the student's profile with the resource ratings. Next the CGI dynamically creates an HTML page containing an ordered list of the educational resources, from the most to the least effective from the student's learning style point of view. So Carver et al. (1999) don't actually propose a fully integrated adaptive educational system, but just a CGI script that applies the fragment sorting technique on an already existing hypermedia course.

The informal experimental evaluations showed the benefits of using this hypermedia course: an increase in the students' learning gain as well as a reduction in the students' requests for additional instruction outside the classroom. However, the learning gain was not evenly distributed among students, with best learners benefiting more from the courseware and weakest learners benefiting less.

- Bajraktarevic et al. (2003) devised a Geography course for 14-year old students, individualized according to the FSLSM sequential / global preference. Namely, the course content is presented in a specific layout: pages for global students contain diagrams, table of contents, overview of information, summary, while pages for sequential learners only include small

Table 1. Overview of papers on personalized courses with respect to learning styles

Paper	Course subject	Learning style model	Adaptation techniques	Experimental validation
(Carver et al., 1999)	Computer Systems	FSLSM (sensing/intuitive, visual/verbal, sequential/global)	Fragment sorting	Yes
(Bajraktarevic et al., 2003)	Geography	FSLSM (sequential/global)	Customize system's interface	Yes
(Papanikolaou et al., 2003)	Computer Architecture	Honey and Mumford model	Fragment sorting	Yes
(Triantafillou et al., 2004)	Multimedia Technology Systems	Witkin's field dependence /field independence	Conditional text and page variants	Yes
(Cha et al., 2006)	Heritage Alive of an Old Temple	FSLSM	Customize system's interface	No
(Graf et al., 2009)	Object Oriented Modeling	FSLSM (active/reflective, sensing/intuitive, sequential/global)	Fragment sorting	Yes
Current	*Artificial Intelligence*	*ULSM*	*Fragment sorting and adaptive annotation*	*Yes*

pieces of information, and Forward and Back buttons. Just as in the previous case, Bajraktarevic et al. (2003) don't propose a fully integrated adaptive educational system, but just user interface templates tailored for sequential/global students.

The empirical study involved 22 14-year old students, who achieved significantly higher scores while browsing the session that matched their learning styles; however, no significant difference between browsing times for the matched and mismatched groups were found.

- Papanikolaou et al. (2003) devised a course module on "Computer Architecture", using the INSPIRE educational platform. The system uses adaptive presentation techniques to adapt the learning content to the 4 learning styles in Honey and Mumford model (2000): Activist, Pragmatist, Reflector and Theorist. All learners are presented with the same knowledge modules, but their order and appearance (either embedded in the page or presented as links) differs for each learning style. Thus for Activists (who are motivated by experimentation and challenging tasks), the module "Activity" appears at the top of the page, followed by links to examples, theory and exercises. In case of Pragmatists (who are motivated by trying out theories and techniques), the module "Exercise" appears at the top of the page, followed by links to examples, theory and activities. Similarly, in case of Reflectors the order of modules is: examples, theory, exercises, and activities, while in case of Theorists the order is: theory, examples, exercises and activities. The system offers also the students the possibility to choose their preferred order of studying. Furthermore, INSIPRE includes also adaptation strategies based on the students' knowledge level, in the form of curriculum sequencing and adaptive navigation support.

The empirical study involved 23 undergraduate learners of the Department of Informatics and Telecommunications of the University of Athens. According to the opinion surveys, learners were quite satisfied with being offered several types of educational material in a specific order, which apparently facilitated their study.

- Triantafillou et al. (2004) devised a course on "Multimedia Technology Systems" for fourth-year undergraduate students. The course was implemented using the AES-CS adaptive educational system. The platform makes use of both adaptive presentation technique and adaptive navigation support to individualize the information and the learning path to the field dependence (FD)/field independence (FI) characteristic of the students (Witkin, 1962).

Specifically, AES-CS uses conditional text and page variants to present the information in a different style: from specific to general in case of FI learners (who have an analytic preference) and from general to specific in case of FD learners (who have a global preference). AES-CS offers also two control options: program control for FD learners, by means of which the system guides the learner through the learning material; learner control for FI learners, by means of which the learners can choose their own learning paths, through a menu. Since FD learners benefit more from instructions and feedback, an additional frame at the bottom of the page is used to provide them with explicit directions and guidance. This frame is missing in case of FI learners, who prefer few instructions and feedback. Similarly, in case of self-assessment tests, the feedback provided for FI learners is less extensive than in case of FD learners. Another feature offered for FD learners is an *advance* organizer (i.e., a bridging strategy offered at the beginning of a new unit, providing connections with the other units); conversely, FI learners are provided with a *post* organizer (i.e., a synopsis located at the end of a unit).

Finally, FI learners are allowed to develop their own course structure, while FD learners are offered two navigational tools in order to help them structure the learning material and create the big picture: a concept map (a visual representation of the domain concepts and the relations between them) and a graphic path indicator (presenting the current, the previous and the next topic). Furthermore, AES-CS allows all students to modify the adaptation options provided by the system, making their own choices between program / learner control, minimal / maximal feedback etc. It should be mentioned that AES-CS includes also adaptation strategies based on students' knowledge level, in the form of adaptive navigation support. More specifically, it uses adaptive annotation (blue for "recommended" links and grey for "not ready to be learned" links), as well as direct guidance (the most suitable sequence of knowledge units to study).

The empirical study involving 76 undergraduate students showed a positive effect of adaptation, reflected in an increased performance (particularly in case of FD learners) and a high degree of learner satisfaction.

- Cha et al. (2006) devised a course on "Heritage alive of an old temple", individualized according to FSLSM. More specifically, the interface is adaptively customized: it contains 3 pairs of widget placeholders (text/image, audio/video, Q&A board/ Bulletin Board), each pair consisting of a primary and a secondary information area. The space allocated on the screen for each widget varies according to the student's FSLSM dimension: e.g. for a Visual learner the image data widget is located in the primary information area, which is larger than the text data widget; the two widgets are swapped in case of a Verbal learner. Similarly, the Q&A Board and Bulletin Board are swapped in case of the Active versus Reflective learners.

No experimental data is available for this course.

- Graf et al. (2009) devised a course on "Object Oriented Modeling" for undergraduate students, individualized to three FSLSM dimensions (active/reflective, sensing/ intuitive, sequential/global). The course was deployed in Moodle Learning Management System (Moodle, 2009), which was extended with an add-on providing the required adaptation. More specifically, it provides an individualized sequence and number of learning objects of each type (examples, exercises, self assessment tests, content objects).

The empirical study involving 147 students showed that adaptivity has the potential to support learners, having however different effects for learners with different learning styles.

As far as the course authoring process is concerned, most of the existing LSAES offer no support for the teacher, providing no dedicated authoring tool, with the notable exception of AHA! (version 3.0) (Stash, 2007). Unlike these systems, which only provide functionalities for the students, WELSA caters also for the teacher as we will show in the next section. A further difference from the above mentioned works is that our AI course is personalized according to a complex of learning preferences (distilled in ULSM), and not to one of the traditional learning style models. Finally, there are also differences in terms of the adaptation mechanism used, as shown in the next sections.

TEACHER'S PERSPECTIVE (COURSE AUTHORING)

The process of authoring adaptive hypermedia involves several steps (Stash et al., 2005):

- Creating the actual content (which should include alternatives to correspond to various learner needs, in terms of media type, instructional role, difficulty level etc)

- Creating the domain model (defining the concepts that are to be taught and the prerequisite relations between them).
- Specifying the criteria to be used for adaptation (e.g., knowledge level, goals, learning style).
- Creating the adaptation model (defining the rules for learner modeling and adaptation logic).

In case of WELSA, authors only have to create the actual content and annotate it with a predefined set of metadata (provide the static description). These metadata also include information about the hierarchical and prerequisite relations between concepts, as we will see later on. The criteria to be used for adaptation are the learning preferences of the students, as defined in ULSM (Popescu, 2010a). Finally, the adaptation model (the dynamic description) is supplied by the application, in the form of a predefined set of adaptation rules (Popescu & Badica, 2009).

In order to support the teacher in creating courses conforming to WELSA internal format, we have designed a course editor tool, which allows authors to easily assemble and annotate learning resources, automatically generating the appropriate file structure. It should be noted that WELSA course editor does not deal with the creation of actual content (text, images, simulations etc) – a variety of existing dedicated tools can be used for this purpose (text editors, graphics editors, HTML editors etc). Instead, WELSA course editor provides a tool for adding metadata to existing learning resources and defining the course structure (specifying the order of resources, assembling learning objects in pages, sections and subsections) (Popescu et al., 2008a).

The course structure that we propose in WELSA is a hierarchical one: each course consists of several chapters, and each chapter can contain several sections and subsections. The lowest level subsection contains the actual educational resources. Each such elementary learning object (LO) corresponds to a physical file and has a metadata file associated to it (Popescu et al., 2008b). Apart from being widely used for organizing the teaching materials, this approach also insures a high reusability degree of the educational resources. Furthermore, due to the fine granularity level of the LOs, a fine granularity of adaptation actions can also be envisaged. Finally, since each LO has a comprehensive metadata file associated to it, we know all the information about the learning resource that is accessed by the learner at a particular moment, so we can perform a detailed learner tracking.

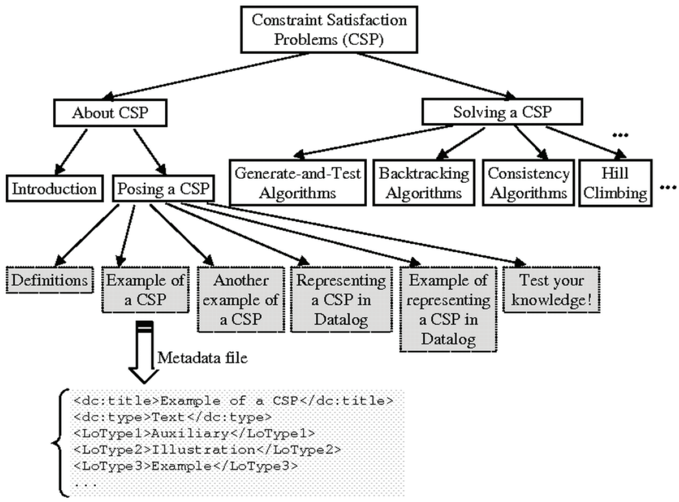
Figure 1 shows the hierarchical structure of one of the chapters in the AI course, namely the one on "Constraint satisfaction problems (CSP)". The corresponding XML files can be seen in Figure 2 (XML for chapter and metadata respectively).

The teacher can define this chapter structure in a simple and intuitive way, by using the course editor, as shown in Figure 3. The corresponding XML files (i.e., those from Figure 2) are subsequently generated by the application and stored on the server.

A few explanations regarding metadata are in order. One possible approach would be to associate to each learning object the learning style that it is most suitable for. One of the disadvantages is that this approach is tied to a particular learning style. Moreover, the teacher must create different learning objects for each learning style dimension and label them as such. This implies an increase in the workload of the teacher, and also the necessity that she/he possesses knowledge in the learning style theory. Instead, we propose a set of metadata that describe the learning object from the point of view of instructional role, media type, level of abstractness and formality, type of competence etc. These metadata were created by enhancing core parts of Dublin Core (DCMI, 2009) and Ullrich's instructional ontology (Ullrich, 2005), with some extensions to cover the requirements specific to learning styles.

Thus some of the descriptors of a learning object are (Popescu et al., 2008b):

Figure 1. Hierarchical structure of CSP chapter (white boxes designate sections and subsections, while grey boxes designate LOs)



- Title (the name given to the resource) → *dc:title.*
- Identifier (a reference to the actual resource, such as its URL) → *dc:identifier.*
- Type (the nature of the content of the resource, such as text, image, animation, sound, video) → *dc:type.*
- Format (the physical or digital manifestation of the resource, such as the media type or dimensions of the resource) → *dc:format.*
- Instructional role, either i) fundamental: definition, fact, law (law of nature, theorem, policy) and process or ii) auxiliary: evidence (demonstration, proof), explanation (introduction, conclusion, remark, synthesis, objectives, additional information), illustration (example, counter example, case study) and interactivity (exercise, exploration, invitation, real-world problem) → *LoType1, LoType2, LoType3, LoType4.*
- Related learning objects: i) *isFor / inverseIsFor* (relating an auxiliary learning object to the fundamental learning object it completes); ii) *requires / isRequiredBy* (relating a learning object to its prerequisites); iii) *isA / inverseIsA* (relating a learning object to its parent concept); iv) *isAnalogous* (relating two learning objects with similar content, but differing in media type or level of formality).

This mechanism reduces the workload of authors, who only need to annotate their LOs with standard metadata and do not need to be pedagogical experts (neither for associating LOs with learning styles, nor for devising adaptation strategies). The only condition for LOs is to be as independent from each other as possible, without cross-references and transition phrases, to insure that the adaptation component can safely apply reordering techniques. Obviously, there are cases in which changing the order of the learning content is not desirable; in this case the resources should be presented in the predefined order only, independently of the student's preferences (the teacher has the possibility to specify these cases by means of the prerequisites mechanism, e.g., *requires/ isRequiredBy*).

Also authors should ideally provide as many equivalent LOs as possible, but represented in different media formats, different level of abstractness and formality etc. Of course, this

Figure 2. XML files for chapter structure (left-hand side) and LO metadata (right-hand side)

```
<?xml version="1.0" encoding="UTF-8"?>
<Chapter xmlns:dc="http://purl.org/dc/elements/1.1/"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="chapter.xsd"
    xsi:schemaLocation="http://purl.org/dc/elements/1.1/
    http://dublincore.org/schemas/xmls/qdc/2006/01/06/dc.xsd ">
    <About>
        <title>Constraint Satisfaction Problems</title>
        <creator>Elvira Popescu</creator>
        ...
    </About>
    <Content>
        <Div1>
            <Title>About CSP</Title>
            <Div2>
                <Title></Title>
                <Div3>
                    <Title>Introduction</Title>
                    <Div4>
                        <Title></Title>
                        <LO>csp_def_informal.xml</LO>
                        <LO>csp_remark_graph.xml</LO>
                    </Div4>
                </Div3>
                <Div3>
                    <Title>Posing a CSP</Title>
                    <Div4>
                        <Title></Title>
                        <LO>csp_def_formal.xml</LO>
                        <LO>csp_example1.xml</LO>
                        <LO>csp_example2.xml</LO>
                        <LO>csp_datalog.xml</LO>
                        <LO>csp_datalog_example.xml</LO>
                        <LO>csp_exercises.xml</LO>
                    </Div4>
                </Div3>
            </Div2>
        </Div1>
        <Div1>
            <Title>Solving a CSP</Title>
            <Div2>
                <Title></Title>
                <Div3>
                    <Title>Generate-and-Test Algorithms</Title>
                    <Div4>
                        <Title></Title>
                        <LO>generate_test_procedure.xml</LO>
                        <LO>generate_test_example.xml</LO>
                    </Div4>
            ...
        </Div1>
    </Content>
</Chapter>
```

```
<?xml version="1.0" encoding="UTF-8"?> <LO
xmlns:dc="http://purl.org/dc/elements/1.1/"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="metadata.xsd"
    xsi:schemaLocation="http://purl.org/dc/elements/1.1/
    http://dublincore.org/schemas/xmls/qdc/2006/01/06/dc.xsd ">
    <title>Example of a CSP</title>
    <identifier>csp_example1.html</identifier>
    <type>Text</type>
    <format>text/html</format>
    ...
    <LoType1>Auxiliary</LoType1>
    <LoType2>Illustration</LoType2>
    <LoType3>Example</LoType3>
    <hasAbstractness>concrete</hasAbstractness>
    <hasFormalness>informal</hasFormalness>
</LO>
```

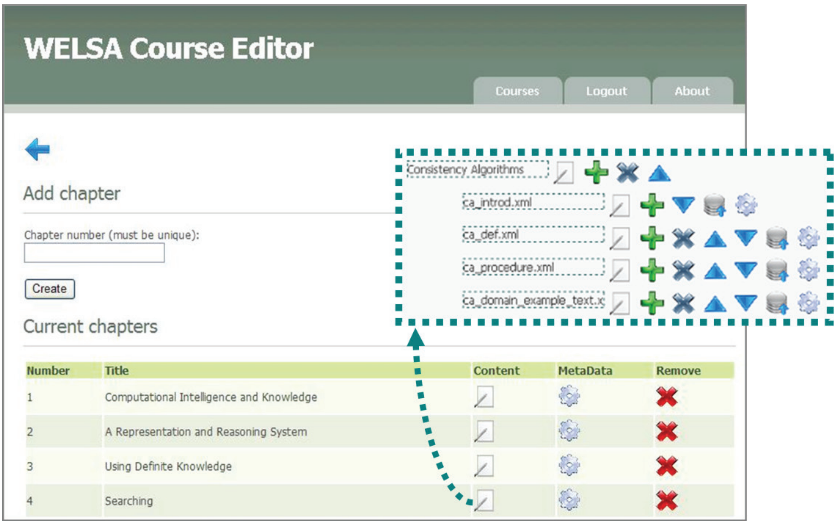
might not be always feasible. Just as Gardner said about customizing the learning material to fit the seven intelligence types, "there is no point in assuming that every topic can be effectively approached in at least seven ways, and it is a waste of effort and time to attempt to do this" (Gardner, 1995, p. 206). However, our AI module is an example of a successful case; it was devised starting from an existing course, with little additional work from the teacher; the adaptation results were highly satisfactory, as we will see in the next section.

STUDENT'S PERSPECTIVE (COURSE VISUALIZATION)

Once the course files are created and stored by the Authoring tool, the Adaptation component is needed in order to generate the individualized web pages that will be shown to each student.

More specifically, each time an HTTP request is received by the server, the adaptation component queries the learner model database, in order to find the ULSM preferences of the current student. Based on these preferences, the component applies the corresponding adapta-

Figure 3. Snapshot of WELSA authoring tool: adding chapters (main window) & editing chapter structure (dotted box)



tion rules and generates the new HTML page (see Figure 4).

These adaptation rules make use of sorting and adaptive annotation techniques, to recommend students the most suited learning objects and learning path. The popular "traffic light metaphor" is also used, to differentiate between recommended LOs (with a highlighted green title), standard LOs (with a black title) and not recommended LOs (with a dimmed light grey title). Basically, these rules are aggregated from elementary actions, such as annotating, inserting, eliminating, sorting or moving learning objects. They also involve the use of LO metadata, which convey enough information to allow for the adaptation decision making (i.e., media type, level of abstractness, instructional role etc).

In what follows we will show the way this adaptation mechanism is visualized by the students, in the Web browser. Let us take a student who has a preference towards *Visual* perception modality and *Concrete, practical examples* (among other ULSM characteristics). The rules in Box 1 will be applied for this student:

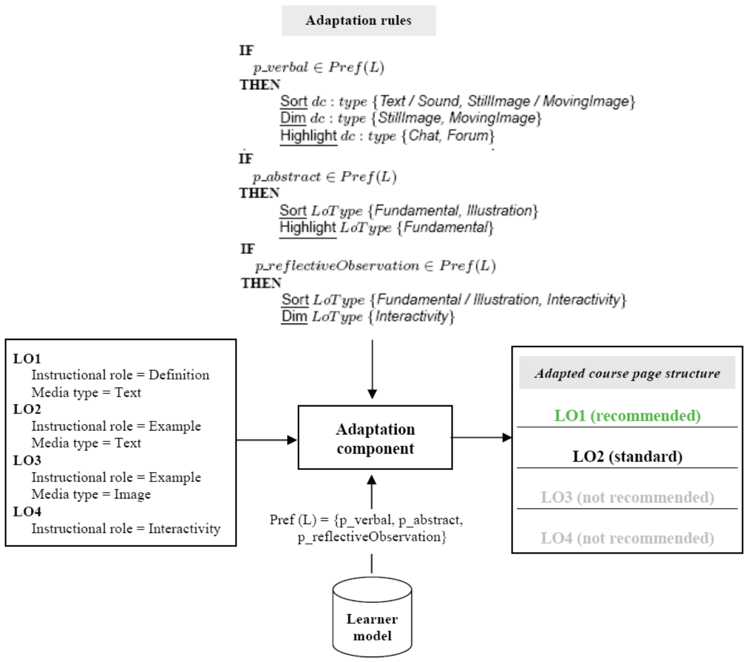
Consequently, the course page on "Posing a CSP" (Figure 5) will start with two recommended (green-titled) examples followed by a definition, since the student prefers the abstract concepts to be first illustrated to her by concrete, practical examples. Similarly, for the "Breadth-First Search Algorithm" page, the graphical animated example is placed first and marked as recommended, while the text-based one is placed second and marked as less recommended, since the student has a predominantly visual preference (Figure 6).

COURSE VALIDATION

Student Validation

In order to validate our WELSA AI course, we tested it with 42 undergraduate students from the field of Computer Science at the University of Craiova, Romania. After following the AI course, students had to fill in a questionnaire regarding their learning experience with WELSA system. First, they were asked to assess the course content, the presentation, the platform interface, the navigation options, the communication tools and the course as a whole, on a 1 to 10 scale. The results are presented in Figure 7.

Figure 4. Automatic generation of an adapted course page for a student with preferences towards Verbal perception modality, Abstract concepts and Reflective observation



Box 1.

Adaptation rule for learners with "Visual" preference

IF

$$p\_visual \in \Pr ef(L)$$

THEN

Sort*dc: type {StillImage/MovingImage, Text/Sound}*

Dim*dc: type {Text, Sound}*

Adaptation rule for learners with "Concrete" preference

IF

$$p\_concrete \in \Pr ef(L)$$

THEN

Sort *LoType {Illustration, Fundamental}*

Highlight*LoType {Illustration}*

As we can see from Figure 7, the students' evaluation of the AI course and WELSA platform is very positive. 71.42% of the students assessed the course content as very good (marks 9-10), 26.19% as good (marks 7-8) and only one student as average. As far as the presentation is concerned, the majority of the students (88.09%) found it very enjoyable, while the rest of 11.91% were also quite pleased with it. Students declared themselves equally satisfied with the course interface, 85.71% of them assigning it marks 9 and 10 and 14.29% marks 7 and 8. Students also appreciated positively the navigation features offered by the system, 80.95% of them giving very high marks (9-10). The lowest marks were obtained by the com-

Figure 5. Snapshot from WELSA AI course: a page adapted for a student with Concrete learning preference

munication tools, with an average of only 7.54. This can be explained by the quite basic tools offered (chat and forum), while students were expecting more advanced communication tools (like audio / video conference, whiteboard, blog etc). The course as a whole received very high marks (9-10) from 85.71% of the students, the rest evaluating it as quite good (marks 7-8).

All in all, very good marks were assigned to most of the features, with only one feature (the communication tools) receiving lower (but still satisfactory) ratings. We can therefore conclude that students had a very positive learning experience with WELSA.

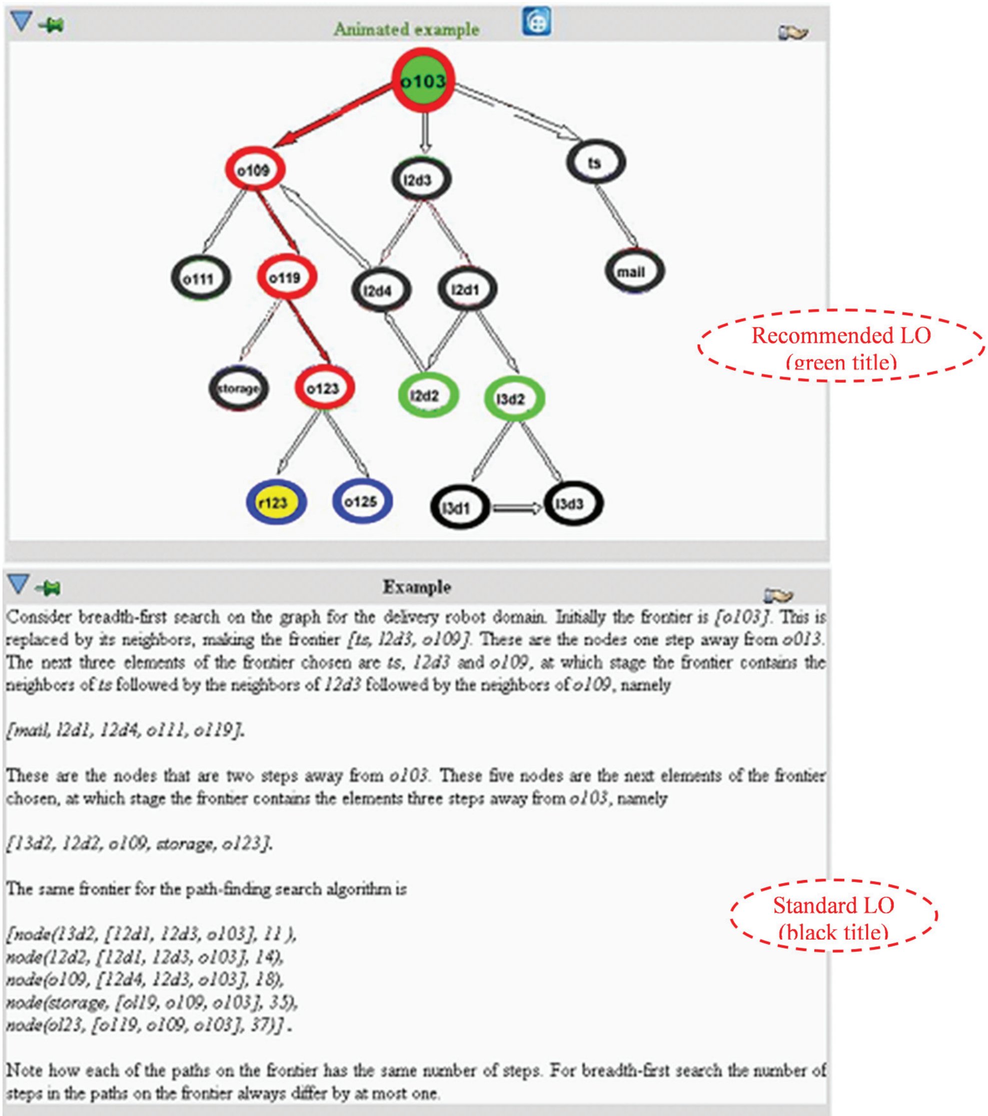
The main goal of our course was the provisioning of an adaptive learning experience. Therefore, evaluating the adaptivity features of the system is of a particular importance. We were first interested in finding out the perceived degree of concordance between the course and the students' self-diagnosed learning preferences. "To which extent do you believe the course matched your real learning preferences?" was the question addressed to the students. The subjects could choose from a 5-point-scale ("Very large", "Large", "Moderate", "Small", "Very small"). The results are presented in Figure 8, showing a good correspondence between the adapted course and the students' real learning preferences.

The next survey item aimed at identifying the extent of the adaptation effect on the learning process. Students' answers to the question: "To which extent was this adaptation useful for you?" are summarized in Figure 9. As you can see, the majority of the students (80.95%) reported that the adaptation provided by the system proved useful for their learning process, at least to a moderate extent.

Finally, we were interested in students' desire to use WELSA system for other courses, on an everyday basis. The results are summarized in Figure 10. As can be seen from the figures, the large majority of the students (83.33%) are ready to adopt WELSA system for large scale use, with only 7.14% reluctant.

More evaluations regarding the adaptivity features of WELSA, coming from different

Figure 6. Snapshot from WELSA AI course: a page adapted for a student with Visual learning preference



experiments, were reported in (Popescu, 2010b), including comparisons between the adaptive and non-adaptive sessions as well as between matched and mismatched learners. The overall results are very encouraging, proving the positive effect that our adaptation to learning styles has on the learning process.

Teacher Validation

The implementation of the AI course in WELSA started from an existent learning material, inspired from the textbook of Poole et al. (1998). The authoring process was quite straightforward, requiring few additions and modifications. The authoring tool proved easy to use,

Figure 7. Students' assessment of their learning experience with WELSA

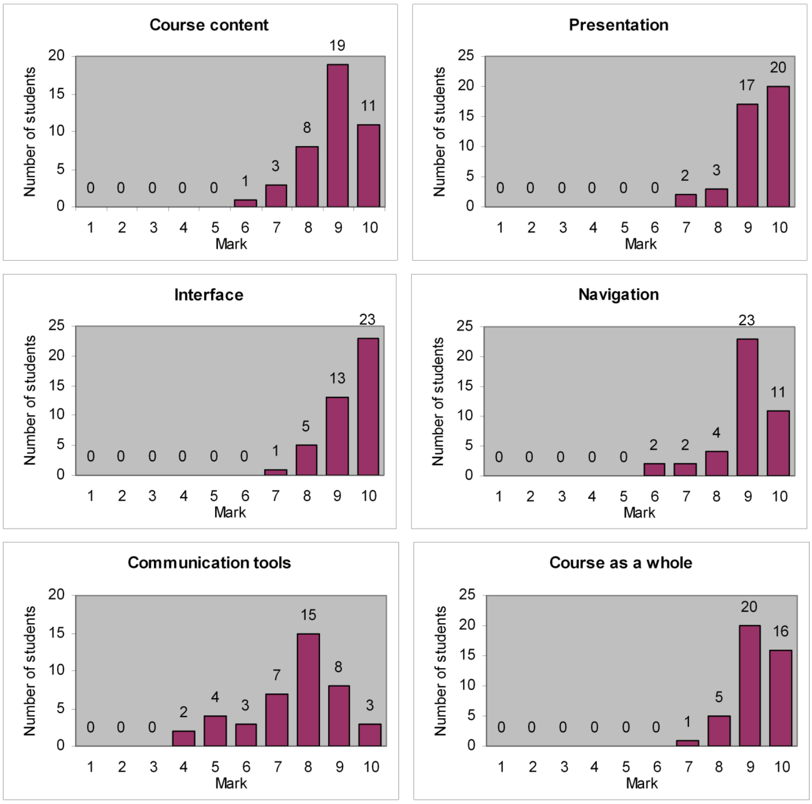
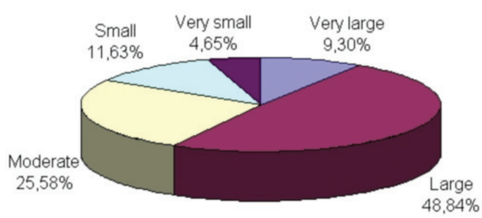


Figure 8. Perceived degree of concordance between the course and the matched students' self-diagnosed learning preferences



both for the initial version and for subsequent editing of the course. Some additional time was required for the creation of videos, animations and interactive simulations, to support learners with visual and/or active preferences. However, as mentioned in section 3, the creation of the actual course content is outside the scope of our system: WELSA authoring tool is only concerned with the structuring and annotating of the LOs, which are presumed already available. From this point of view, the editor tool proved very handy and the authoring process was efficient and enjoyable.

However, in order to validate the WELSA authoring tool, we needed also an independent evaluation, from teachers not engaged in the

Figure 9. Perceived usefulness degree of the adaptation process

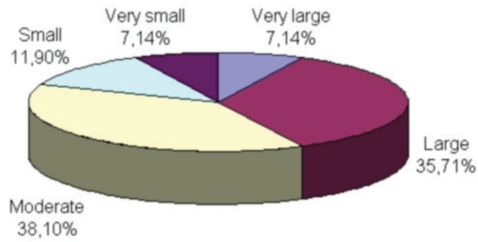
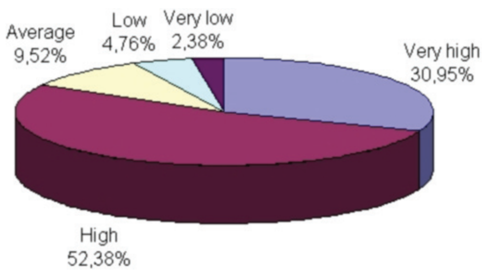


Figure 10. Students' willingness to adopt WELSA system for everyday use



WELSA development process. We therefore performed a small experiment involving 3 professors from the Systems Engineering field. First, they went through a training session, where they were familiarized with the principles and functionalities of WELSA, including the course editor. Next, they were asked to use the authoring tool for implementing a course fragment of their choice. Finally, they had to fill in a questionnaire regarding their experience in interacting with WELSA authoring tool. The results of this questionnaire are summarized in Table 2.

We then analyzed the resulted course fragments: all three were correct and complete, with well defined hierarchical organization as well as comprehensive metadata. One thing that we noticed is that teachers tend to create their courses in a quite inflexible manner, defining strict prerequisite relations between LOs, even when this is not needed (which limits the applicability of the resource ordering technique). Perhaps more training and practice would solve this problem. Furthermore, not enough multimedia LOs were provided, which means that Visual learners are not well catered for; similarly, not enough opportunities for practice (simulations, interactive resources) were included, which means limited support for Active learners. However, we should point out that these limitations pertain to the course itself, not to the WELSA system.

Finally, while the 3 teachers assessed the tool as intuitive and easy to learn and encountered no problems while using it, we should not forget that they all come from a technical field. Perhaps for less technical-oriented authors a graphical tool for expressing hierarchical and prerequisite relations between LOs, as well as drag-and-drop facilities for positioning the LOs in the course, would be more welcome. Furthermore, a preview option could be added, as suggested by Teacher_1.

CONCLUSION

This paper reported a case study on the implementation of a personalized AI course using WELSA educational system. Several steps were covered: i) course authoring; ii) adaptation mechanism;

Table 2. Teachers' assessment of their authoring experience with WELSA course editor

Question	Teacher_1	Teacher_2	Teacher_3
How much time did you spend with WELSA Authoring tool?	4h	3h	4.5h
Did you understand how to work with the tool? (Yes / No)	Yes	Yes	Yes
Was it easy to learn to work with the tool? (Very easy / Easy / Average / Difficult / Very difficult)	Very easy	Easy	Easy
Was the interface intuitive? (Very intuitive / Intuitive / Average / Not very intuitive / Not at all intuitive)	Very intuitive	Intuitive	Very intuitive
Did you experience any problems with the tool? (Yes/No) Please describe	No	No	No
Did you get the results that you expected? (Yes/No)	Yes	Yes	Yes
Are you satisfied with the resulted course? (Very satisfied / Satisfied / Neutral / Unsatisfied / Very unsatisfied)	Satisfied	Satisfied	Very satisfied
Overall impression (pleasant / unpleasant; easy / difficult)	Pleasant, easy	Pleasant, easy	Pleasant, easy
Suggestions and comments	"It would be nice to have the possibility to visualize the resulted course as you add LOs (preview)"	"My original course doesn't include any simulations / interactive resources and it would take a lot of time to make them"	"The course looks really nice and I'd like to actually use it with my students. I would probably have to add more interactive resources, though"

iii) experimental validation. The results obtained are very encouraging, proving the practical applicability of WELSA system, both from the point of view of the students and the teachers.

However, in order to allow for generalization, more courses in various domains have to be implemented in WELSA. Furthermore, the system will have to be tested on a wider scale, with students of variable age, field of study and background knowledge, as well as with teachers having various degrees of technical experience.

Another future research direction would be to offer students a wider variety of adaptation strategies, by extending the adaptation component. Additionally, as students suggested in the opinion questionnaire, more advanced communication and collaboration tools should be incorporated, including Web 2.0 applications (blog, wiki, social bookmarking tool etc).

Further support could also be provided for the teacher (course author): adding an import / export facility to the course editor, allowing for conversion between various course formats and standards (e.g. SCORM, IMS LD etc) would be very helpful. This would allow teachers to use existing courses as they are (perhaps adding some additional metadata), which would provide for greater reuse.

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