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An Architecture of Adaptive Online Module System Based on Felder-Silverman Learning Style Model

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***Abstract*—Students will get some benefits by knowing their own learning style. The adaptive online module system gives students a learning environment that adapting to their learning style. The architecture of the adaptive online module system consists of a domain model, media space, student model, instruction model, adaptive model and user interface. The system identifies student learning style using a questionnaire based on the Felder-Silverman Learning Style Model (FSLSM). The stereotype of student learning style stored in the student model. The adaptive model delivers the appropriate learning experience based on the student model. The adaptability is delivered in the form of adaptive content and adaptive navigation.**

Keywords: architecture, adaptive online, module system, Felder-Silverman Learning Model

I. INTRODUCTION

Students will get some benefits by knowing their own learning style. First, it will raise students' awareness of their learning styles and the impact of the learning styles into their lesson. Students may also use the awareness to understand the difficulties they met in learning and creating some groundwork to overcome their weakness. Second, student style information can be used to provide learning activities or materials and personalization recommendations according to their learning style [1].

The student learning style is the first thing to acknowledge when considering learning styles in education. Brusilovsky [2] mention that there are two kinds of student modeling. The first one is a collaborative approach. In this model, the student explicitly provides feedback that can be used to build and update the student's model. For example, the student gives data for the student modeling process by declaring the relevancy of content for their learning objectives explicitly. Another form in this modeling is letting the students adapt by themselves and show directly their expectations of the system. For example, students may rearrange link sequence in a page, showing their preference sequence of a system. Another possibility is by allowing the student to change and update directly the student model information. Regarding learning styles, the means frequently used is by asking students to fill a questionnaire which will give the required information about their learning styles. Second, modeling is an automatic approach in which the building and updating process of the model happened automatically based on the students' behavior while using the system for learning. [2].

There are two styles in student modeling, i.e. static and dynamic. In the static modeling style, the modeling process takes place at the beginning of the learning process so the information of the student model is stored once. In learning system application, students need to supply the information as a new user. While on dynamic student modeling, the modeling process happened on more than one occasion which allows the system to update information about the student model frequently. The dynamic student modeling, allowing the system to respond appropriately to the changes in the student behavior [1].

Several studies on adaptive learning system developments have been made. The studies based on an adaptation of learning style with a questionnaire as the tool (using static and collaborative approach). Some of the studies are CS383 [3], IDEAL [4], LSAS [5], and WHURLE [6]. In this paper, an adaptive system architecture will also be implemented into an adaptive online module system by integrating student modeling within the system. Through static student modeling, which will understand the students learning style using the questionnaire, and store the information into student models, the system may access the needed information to give adaptive and personalized learning material for students. Adaptive system architecture, as well as some support system, integrated into the adaptive online module system to provide students with adaptive support.

This study is based on the Felder-Silverman Learning Style Model (FSLSM) [7] which consider that every student has a preference in each of the four dimensions: processing (active/reflective), understanding (sequential/global), input (visual/verbal), and perception (sensing / intuitive). FSLSM is a learning style model that explains the learning style in detail and very well suited to accomplish the adaptability of a learning system [8]. It is the reason FSLSM, on many occasions, acts as a basis in the learning enhancement system. FSLSM, based on the concept of the tendency, consider learning style rather as the main tendency than fixed and static which in return allowed to handle exceptional behavior from the student. While FSLSM considers that the tendency more or less stays the same, it also opened to the possibility that the tendency may change from time to time. The tendency changing is known to be domain-independent.

After the student model stores the information about the student, adaptability may be given. Consideration of some different aspects is taken when targeting students with customized learning for them. One dimension considers what may be customized in the system. Different methods are available to deliver adaptive learning for students. The methods define the appropriate features of the systems for the specified students. Brusilovsky [9] defines the adaptability of the system, based on the purpose, into two areas, adaptive presentation, and adaptive navigation. Adaptive presentation is a feature that changes the presentation of learning content such as, presenting the content in text or multimedia or the modality of content, all in an adaptive manner. Whereas adaptive navigation conducted by manipulating links which include features like a direct guide, adaptive map, adaptive sorting, hiding, annotation, and link generator.

Both features can be used together, for example, changing the navigation using the predetermined rule while at the same time changing the presentation, either deliver the content in text form or multimedia form, using the rules that had been set.

II. RELATED WORK

Several other adaptive learning systems which are based on learning style adaptation using questionnaire have been done. Learning Style Adaptive System (LSAS) by Bajraktarevic et al [5] utilizes only one dimension from FSLSM (Felder and Silverman Learning Style Model), which is understanding, a dimension of sequential/global. In order to gather information about student learning styles, the system uses the ILS (Index of Learning Style by Felder and Soloman [10]) questionnaire. The adaptability of the system delivered by two different templates of the user interface. Each page for the student with sequential preference contains a small part of the information in the form of text only. To navigate from the page, 'forward' and 'back' link/buttons provided to deliver a linear learning path. Meanwhile, a student with a global preference has an advantage in terms of navigation. The page contains several elements such as a table of contents, page overview, related links in the text as well as a section with additional links and a summary at the end of the page. The provided elements give students an overview of the selected topic and give an opportunity to roam freely using a numerous choice of links. An experiment that involves 21 students is conducted to evaluate the effectiveness and the adaptability of the system. The experiment consists of 2 parts. In the first part of the experiment, students use the system which behaves appropriately to their learning style. In the second part, the students use the system which behaves opposite to their learning style. Based on the pre-install on post result, the students significantly perform better when the system behavior suited their learning style.

Brown et al [6] developed the WHURLE (Web-based Hierarchical Universal Reactive Learning Environment). WHURLE based on ILS but only utilize the visual/verbal dimension (input dimension). Under the condition, the questionnaire consists of 11 items only. Brown et al [6] successfully integrated the visual/verbal learning style with the adaptive learning system. The experiment also held to understand the impact of the adaptive system. The experiment gives results in quantitative and qualitative data. Based on quantitative data, there is no significant difference from the adaptive system compared to the traditional approach. Meanwhile, based on the qualitative data, students show their preference for the adaptive system rather than the traditional approach. The students think that a personalized system shows that need is acknowledged and fulfilled while the traditional approach is a 'one size fits all'. This kind of information is often missed on empirical studies while still important part when evaluating the system. This study shows that learning styles integration into an adaptive hypermedia system is possible and the result is promising in motivating the student while the academic result itself unaffected.

III. STUDENT MODEL BASED ON LEARNING STYLE

The student model is an abstract representation of the student in the adaptive online module system. There are two important processes of how this adaptive online module system realizes its adaptive function. First, the adaptive online module system should collect data on students, then process the data to regulate the student model, called student modeling. Later, the system should apply the student model to behave in an adaptive manner.

The student model designed in this study is composed of the profile of the student, the learning history, and the learning style. Student profiles store basic individual information, such as names, user names, and passwords, as well as other individualized information so that the system can identify the student. The learning history stores the learning process of the learner's students, such as the subjects being studied by the students and participation in the discussion. This history facilitates the teacher or lecturer to understand the student. The learning style of the student is a very important dimension in the student model, as it is the key to achieving adaptability in the adaptive online module system. Researchers use stereotypes to represent student learning styles.

One student has a different learning style compared to the others, and the different learning styles correspond to different teaching styles as well. For example, some students prefer to receive better information through visual sensor channels or while others auditory canal channels. In this case, the learning process for the first kind of students is better adapted with visual materials (such as images) while the second students using sound or text (composed of words, then connected with auditory information processing).

Learning styles can be represented in a stereotypical model based on the Felder-Silverman Learning Style Model. The model consists of four dimensions, perception, input, processing and understanding. The dimensions are described as follows [11] :

1. Perception describes the level of abstraction of the learning material favored by the student. Consists of sensing students and intuitive students. Sensing students liked the fact and require more practice case study, while the intuitive student usually prefers innovation and dislike repetition
2. Input dimension indicates whether the student prefers listening (textual) documents or visual documents. The students who fall into the category called the verbal student and visual student accordingly.

3. Processing dimension indicates the student's preference in processing information. The active students like to involve in activities or discussion while reflective students prefer to introspect the lesson by themselves.
4. Understanding dimension indicates which progress students understand better. Sequential students prefer an explanation in the form of sequence. Meanwhile, global students prefer an overview of the selected topic and shown steps and relationships of the learning material.

IV. ARCHITECTURE OF ADAPTIVE ONLINE MODULE SYSTEM

This adaptive online module system has a main architecture consisting of media space, domain model, student model, instruction model, adaptive model and user interface, as shown in figure 1.

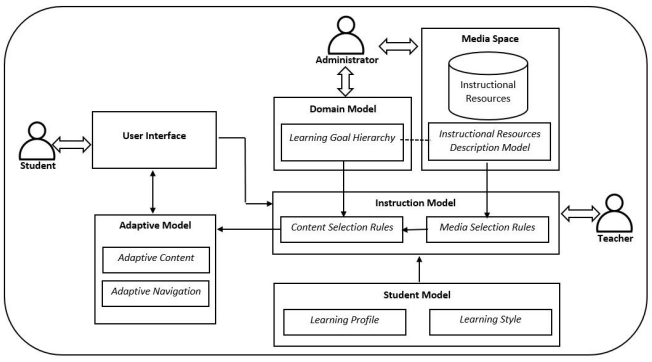

Figure 1. Architecture of adaptive online module system based on FSLSM

A. A subsection Domain Model

The domain model holds information on the learning objectives hierarchy. The hierarchy is a structure that manages the learning components and their relationships. The learning components consist of instructional objectives and instructional resources. Such a relationship between the components composes domain knowledge. The domain itself acts as a repository to store and organize the hierarchy in certain areas, like courses.

B. Media Spaces

The media space's main function is storage for instructional resources. Media space uses an instructional resources database to fulfill its purpose. Learning materials stored in the database take various forms. Basic resource available in text form with some images while more sophisticated resources may come in the shape of audio, video or animation

C. Student Model

Student model store learning profile of the student. In the adaptive online module system, students declare their learning profile by filling questionnaire after logged in to the system for the first time. While students may take the questionnaire again, essentially students only need through the process once. Learning profile processed to produce the appropriate learning style. The adaptability of the system is achieved by analyzing the learning style to customize the learning material for each individual

D. Instruction Model

The instruction model is used by the teacher. It stores content selection rules and media selection rules. The teacher determines which content and media will be available for specific learning material. In the process, the teacher needs to determine multiple media for each content, helped by the system, to accommodate the various student learning style. Actually, teachers don't explicitly determine which content and media for a student with a particular learning style. The customization is done by the system so while the teacher simply puts a static / fixed learning material, the student gets an adaptive learning material both in the order/navigation of the material and the content of the material

E. Adaptif Model

The adaptive model is the heart of the whole system. The adaptive model brings adaptability to offer a customized and personalized learning experience to students. Specifically, in the adaptive online module system, there are two adaptabilities offered to students, adaptive content and adaptive navigation.

The adaptive model used previously stored information in the domain model, instruction model, and student model to choose the appropriate content from media space and delivering the adaptive content to students. Adaptive content may vary from choosing the media form (text or picture or others), decision to put summary of the material or giving a quiz to challenge the student

Adaptive navigation also uses the information in the domain model, instruction model, and student model but not from media space. The adaptive navigation determines the sequence of the contents or even the absence of the sequence. Adaptive navigation also determine the available link for each student. While the adaptive content gives different learning material to the student, adaptive navigation may give a whole different experience in exploring the learning material.

F. User Interface

The user interface acts as a medium from the system to students. The user interface generates an interface based on the decision of the adaptive model. If a student makes interaction with the user interface, e.g. clicking a button, then the user interface will send the information to the adaptive model that determines the next content/navigation. The user interface uses the adaptive model decision to generate the next interface.

V. CONCLUSION

The adaptive online module system delivers a learning material that gives adaptive learning experience to the student. The architecture of the system consists of a domain model, media space, student model, instruction model, adaptive model and user interface. At system initiation, the student needs to fill the questionnaire based on the Felder-Silverman Learning Style Model (FSLSM). The information is stored in the student model. The information creates the learning style stereotype of a particular student. The student model is the base for the system to deliver an adaptive learning experience. The system delivers adaptability by

delivering both adaptive content and adaptive navigation. The adaptive model chooses the appropriate learning material from the media space and creates a unique experience by controlling the flow of learning based on the student learning style.

For future work, the proposed architecture may get an advantage by getting feedback from student interaction with the user interface. The proposed architecture currently acknowledges the student learning style based on the questionnaire result. However, the questionnaire result is probably flawed. Such a flaw may happen when the preference of certain styles, based on the questionnaire result, is decided by a small margin. While the original questionnaire method guarantees a result, i.e. a preference, such a case is considered has no real result. Learning the interaction of the student with the user interface may reveal the real student learning style.

Developing the adaptive online module system as mobile application is also considered. Current technology make it possible to put a lot of processing power and storage capacity in a smartphone. A mobile application can make use of those benefits to provide better contents and features compared to web application

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