DYNAMIC ADAPTIVE WEB-BASED MODEL FOR ARCHITECTURAL DESIGN EDUCATION (DAAD)

An e-Learning Environment for An Architectural Design Course

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Abstract

With the advent of the World Wide Web, the Internet has evolved into a user-interactive medium capable of delivering on demand information in high speed. Research into the various methodologies of Web educational applications has been a topic of great interest in the architectural education field. As a course delivery medium, the Web provides the means for creating an integrated, interdisciplinary repository of knowledge available at reasonable cost at anytime, anywhere and to anyone. One of the criteria of an ideal system for facilitating Web-based teaching and learning is to be adaptive. In this paper, we suggest an adaptive Web-based educational model and platform for the architectural design course that supports the main phases of the design process. In particular, the development of the online version of an architectural design course is used as a case study and illustrates the usability of the suggested model.

Keywords:

Architectural design education; web-based learning; information technology.

Introduction

As the scope of the World Wide Web (WWW) expands to include an ever-larger number of applications, education becomes one of them. With the advent of the WWW, the Internet has evolved into a user-interactive medium capable of delivering on demand information in high speed. Research into the various methodologies of Web educational applications has been a topic of great interest in the architectural education field.

In architectural education, the architectural design course, a group of successive studios, is considered as a core course that has significant focus and importance. Many other courses and scientific tracks are employed to serve and enhance the architectural product within the architectural design. This forum of learning is usually considered as the medium of generating creative solutions for given design problems. Therefore, design is often identified as a "problem-solving process". The task of problem-solving can encompass different methods to achieve the best solution of the problem in hand.

The WWW presents some unique advantages as a course delivery medium. One advantage is location transparency. The Web is the distributed file system so that any file on a Web server can be used as though it existed on a local machine. A second advantage of the Web is its availability. Despite rare and irregular service failure, information on the Web is accessible any time. Finally, the Web is a multimedia presentation tool offering text, sound, video, and interactive services. The most significant limiting factor is the bandwidth of the network.

One of the criteria of an ideal system for facilitating Web-based learning is to be adaptive. An adaptive system can dynamically generate course content based on explicit and implicit student feedback. However, there are very few researches for the adaptive Web-based architectural education, especially for the architectural design course. (HOUSING@21.EU, Madrazo and Massey, 2005 - and WINDS, Specht, M. et al. 2002).

Therefore, in this paper, we suggest an adaptive Web-based educational model and platform for the architectural preliminary design courses that supports the main phases of the design process. The model would be flexible and extendable as any other educational tool to cover complex-functions and advanced architectural projects in final years. The suggested system can be a comprehensive tool for design students in adaptive way. In other words, the paths which students take through the course should vary depending on their needs, and the system should actively assist in the identification of the correct path. In particular, the development of the online version of architectural design studio is used as a case study and illustrates the usability of the suggested model.

Background

In this chapter we will go through the main theories and literature review regarding web-based pedagogical theories and models as follows: 2.1) cognitive theory of web-based teaching and learning, 2.2) general web-based educational model, 2.3) adaptive and intelligent web-based educational system. The background knowledge and literature review will be adopted in our model methodology (chapter 3) and then in the model implementation in (chapter 4). Part 2.4 is looking over some case studies of recent researches and the drawbacks noticed in the recent models.

Cognitive Theory of Web-based Teaching and Learning

There are many researches regarding web-based teaching and learning dominion. Among them, we summarize four issues that would be related and applied to the architectural design course as follows:

Self-Directed Learning: Knowles (1975) defines self-directed learning as a process "... in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". Facilitating self-directed learning is also described by Spear and Mocker (1984) as they derived patterns from qualitative research on adult learning that can serve as a basis for organizing the circumstances that affect learning activities.

Brookfield (1986) mentioned the learning contract as a method to facilitate self-directed learning. That would require file management such as uploading and downloading, checking learning process of the students and schedule management functions; in addition to asynchronous communication tools such as e-mailing, discussion groups or chatting room services are necessary as well. Thus it is suggested to apply those tools that facilitate Web-based self-directed learning in our model.

Cognitive Flexibility Theory: Spiro et al. (1992) offer a constructivist theory of learning and instruction that emphasizes the need to treat complex, ill-structured knowledge domains differently from simple well-structured domains. For such ill-structured problems (as in Design) a learning strategy is introduced by that research called the “random access instruction” method that helps the learner to have efficient and flexible cognitive structure and processing to cope with multiple contexts or perspectives.

Spiro et al. (1991) introduced a model for Cognitive Flexibility Hypertext which has many advantages to Web-based education: a) multiple knowledge representations; b) visualizing revision; c) random access instruction; d) supplementary guidance. That would be considerable for architectural design learning as the design is an ill-structured problem and the mentioned theory would support the problem definition stage effectively.

The Goal-Based Scenario: Goal-based scenarios are used as a framework for our learning environment and provide both the scenario context which models real-world applications as well as the scenario structure which settles the features of an adaptive learning environment. Given enough information resources the student should be able to solve the tasks (Schank, 1994). In the anatomy of a goal-based scenario there are four parts: cover story, mission, focus and operations.

To support such a goal-based scenario approach in Web, the concept engagement simulation is useful to build educational environments. We offer several principles to support the concept: 1) simulation-based, learning by doing to obtain authentic skills; 2) adaptive personal mentoring to help students individually; 3) distributed time-independent access to the course knowledge base.

Project-Based Learning: To support the project-based learning approach in Web, we suggest several issues as follows: 1) learning by exploring with an extensible course knowledge base to refer precedents as well as to provide ample and various contents; 2) learning by reflection to get new insights; 3) case-based education to represent knowledge in a realistic and concrete manner; 4) incidental learning to achieve diversity; 5) team-based education to increase learning efficiency and working capabilities.

General Web-based Educational Model

Based on Gagne et al. (2005), we reorganize and develop the procedures and components of a Web-based teaching and learning model.

We define six procedures, each of which has components for the phase in detail, of the Web-based educational model: 1) defining performance objectives; 2) analysis of a learning task; 3) designing instructional sequences; 4) the events of instruction; 5) deciding instructional strategies and delivery methods; 6) assessing student performance (Tables 1, 2, & 3).

Defining Performance Objectives: In general, the instructor defines the learning objectives. There are five components guiding the instructor through performance objectives. The five components are: situation, learned capability, object, action, and tools and constraints.

Analysis of a Learning Task: There are five types of learning outcomes, they are: intellectual skill, cognitive strategies, verbal information, attitudes, and motor skills. The purpose of this five task classification is to provide a basis for designing the conditions necessary for effective instruction.

Designing Instructional Sequences: The instructor decides the sequencing of curriculum or course. The common sequence follows the order of simple to complex skills, the latter of which take a longer time to accomplish. To solve the problems in the design domain, in most of the cases, the design processes are suggested to be followed. Therefore, in design education, the instructor also adopts an educational method that best fits the educational goals.

The Events of Instruction: There are several events that make up instruction for learning outcomes as they may occur within a lesson. Table 2 shows the events of instruction and their relation to processes of learning.

Type of Learning Outcome	Essential Prerequisites	Supportive Prerequisites
Intellectual Skill	Simpler component intellectual skills (rules, concepts, discrimination	Attitudes, cognitive strategies, verbal information
Cognitive Strategies	Specific intellectual skills	Intellectual skill, attitudes, verbal information
Verbal Information	Meaningfully organized sets of information	Language skills, cognitive strategies, attitudes
Attitudes	(Intellectual skills (sometimes (Verbal information (sometimes	Other attitudes, verbal information
Motor Skills	(Part skills (sometimes (Procedural rules (sometimes	Attitudes

Table 1: Essential and Supportive Prerequisites for Five Kinds of Learning Outcomes. (Source: Authors).

Deciding Instructional Strategies and Delivery Methods: Instructional designers and teachers should choose instructional strategies that are most effective for accomplishing a particular learning objective. Instructional delivery strategies can be decided based on different targets (e.g. individual, small group or large group) and learning methods (e.g. lecture, discussion, self-directed, etc).

Instructional delivery methods are the actual mechanisms for delivering instruction. Felder and Silverman developed The Index of Learning Style (ILS) that has four dimensions: Active vs. Reflective; Sensory vs. Intuitive; Visual vs. Verbal; Sequential vs. Global. Table 3 is a reorganization of the relationship between ILS, instructional strategies, and instructional delivery methods as described by Blouin (2003).

Assessing Student Performance: There are basically two types of evaluation: criterion-referenced evaluation and normative-referenced evaluation. In criterion-referenced evaluation the standard for performance is set before assessment, for example 90 percent = A. That is, the standard for acceptable performance can be given to the student ahead of time, and if all students in a class reach the standard we can say the instruction has been successful. The standard in normative-referenced evaluation is set after assessment as a function of the classes' performance. This is generally interpreted as a distribution around the mean or average score on the test. The purpose of normative evaluation is to compare students based on their performance within a specific group.

Instructional Event	Relation to Learning Process
Gaining attention	Reception of patterns of neural impulses
Informing the learner of the objective	Activating a process of executive control
Stimulating recall of prerequisite learned capabilities	Retrieval of prior learning to working memory
Presenting the stimulus material	Emphasizing features for selective perception
Providing learning guidance	Semantic encoding; cues for retrieval
Eliciting performance	Activating response organization
Providing feedback about performance correctness	Establishing reinforcement
Assessing the performance	Activating retrieval; making reinforcement possible
Enhancing retention and transfer	Providing cues and strategies for retrieval

Table 2: Events of Instruction and their Relation to Processes of Learning. (Source: Authors).

Learning Styles	Instructional Strategies	Instructional Delivery Methods
Active	Study in a group in which the members take turns explaining different topics. Work with others to guess what you will be asked on the test and figure out how you will answer.	Discussion, and debate Group work
Reflective	Don't simply read or memorize the material; stop periodically to review what you have read and think about questions or applications. Write short summaries of readings or class notes in your own words.	Time for reflection, journals
Sensory	Ask your instructor for specific examples of concepts and procedures, and find out how the concepts apply in practice. If the teacher does not provide enough specific, try to find some in your course text or other references or by brainstorming with friends.	Real-world applications Hands-on activities
Intuitive	Ask instructor for interpretations, or theories that link the facts. Or try to find the connections yourself.	Connections: concept maps Open-ended, speculative assignments
Visual	Find visual representations of course material. Prepare a concept map by listing key points, enclosing them in boxes or circles. Color code notes with a highlighter.	Diagrams, charts, movies Demonstrations
Verbal	Write summaries or outlines of course material in your own words. Work in groups.	Discussions, oral reports Writing projects
Sequential	Outline lecture material for yourself in a logical manner if the teacher does not do it for you. Strengthen global thinking skills by relating new topics to things you already know.	Outlines, stepwise presentations
Global	Before you begin studying, skin the first section of the text to get an overview. Relate subjects to things you already know.	Topic overviews Connections to other material

Table 3: The Relationship between ILS (Index of Learning Styles), Instructional Strategies and Methods. (Source: Authors).

Adaptive and Intelligent Web-based Educational System

Adaptive and intelligent web-based educational systems (AIWBES, Brusilovsky, 1999) provide an alternative to the traditional "one-size-fits-all" approach in the development of educational courseware. The systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user in order to adapt to the needs of that user (Brusilovsky, 2001). Historically, almost all Web-based educational systems (WBES) are inherited from two earlier systems of WBES: intelligent tutoring systems and adaptive hypermedia systems (Figure 1).

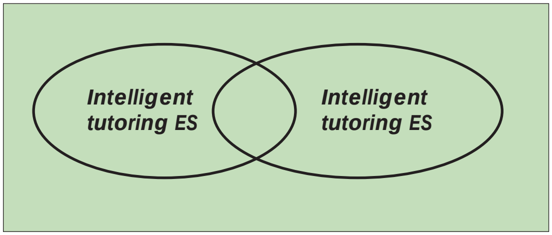


Figure 1: The Relationship between Adaptive and Intelligent Educational Systems.
(Source: Brusilovsky and Peylo, 2003).

Intelligent Tutoring Systems: Intelligent tutoring systems (ITS) apply techniques from the field of Artificial Intelligence (AI) to provide broader and better support for the users of Web-based educational systems (Brusilovsky and Peylo, 2003). The goal of ITS is to use the knowledge about the domain, the learner, and about teaching strategies to support flexible individualized learning and tutoring (Brusilovsky, 1999).

The following is a summary of three major ITS technologies, curriculum sequencing, intelligent solution analysis and problem solving support, as described by Brusilovsky (1999).

Curriculum sequencing
It helps the learner to find an "optimal path" through the learning material by providing the learner with the most suitable individually planned sequence of knowledge (questions, examples, problems, etc).

Intelligent solution analysis
Intelligent analyzers can decide whether the solution is correct or not, find out what exactly is wrong or incomplete, and possibly identify which missing or incorrect knowledge may be responsible for the error.

Problem solving support
It provides the learner with intelligent help on each step of problem solving. The level of help can vary from signaling about a wrong step, to giving a hint, to executing the next step for the learner.

Adaptive Hypermedia Systems: Adaptive hypermedia systems are all hypertext and hypermedia systems that reflect some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user (Brusilovsky, 1996b).

An adaptive hypermedia system collects information about users. On base of these individual characteristics, it adapts its content and navigational possibilities to the particular user.

Adaptive hypermedia systems need data for making assumptions about the user. User's

knowledge, goals, preferences, background, and experience would be considered as well.
There are two major technologies in adaptive hypermedia: 1) adaptive presentation that adapts the content of a hypermedia page to the learner goals, knowledge, and other information stored in the user model) and 2) adaptive navigation support that assists the learner in hyperspace orientation and navigation by changing the appearance of visible links).

Case Studies of Recent Research

The pioneer adaptive and intelligent Web-based educational systems were developed in 1995-1996 by Brusilovsky et al. (1996), Brusilovsky (1996a), De Bra et al. (1998), Nakabayashi et al. (1995), Okazaki et al. (1996). We list several sample systems in recent five years: KBS-Hyperbook (Henze, 2000), ActiveMath (Melis et al., 2001), ELM-ART (Weber and Brusilovsky, 2001) and SQL-Tutor (Mitrovic, 2003). There are two adaptive Web-based systems in architectural design domain. They are: HOUSING@21.EU (Madrazo and Massey, 2005) and WINDS (Specht, M. et al. 2002).

ActiveMath: ActiveMath (Melis et al., 2001) is a generic Web-based learning system that dynamically generates mathematical courses adapted to the learner's goals, preferences, experience, and knowledge. For each learner, the suitable content is retrieved from a knowledge base and the course is generated individually according to pedagogic rules. However, ActiveMath does not offer the communication tools (e.g., discussion lists, chat rooms) so that the learner is not able to ask questions and discuss with another learners on the platform.

ELM-ART: ELM-ART (Weber and Brusilovsky, 2001) is Web-based tutoring systems. ELM-ART II was designed for learning programming in LISP and integrates a LISP compiler. ELM-ART provides adaptive navigation support, course sequencing, individualized diagnosis of student solutions, and example-based problem-solving support. However, the course structure in ELM-ART is predefined so that it is not flexible to support students' individual situation and give appropriate feedbacks.

KBS hyperbook: The goal of the KBS hyperbook (Henze, 2000) is to build a framework for designing and maintaining open, adaptive hypermedia systems in the Internet. The system compares the user's actual knowledge state with knowledge he should have after finishing the book which is considered an advanced step. KBS supports explicitly goal-based learning. Users can define their own learning goals or can request the next learning goal from the system. KBS also adapts to the different learning speeds of the users by supporting this kind of goal oriented learning. However, KBS hyperbook system does not take account of other adaptive criteria such as learner's preferences.

SQL-Tutor: SQL-Tutor (Mitrovic, 2003) is a Web-enabled intelligent system for teaching SQL database language. The system observes learners' actions and adapts to their knowledge and learning abilities. SQL-Tutor system has good adaptability and has a valuable learning assessment. However, the SQL-Tutor lacks interaction and help guidance. If learners meet problems, they would not easily find help to solve such problems.

HOUSING@21.EU: HOUSING@21.EU (Madrazo and Massey, 2005) is a pedagogic research group. The purpose of the research is to study the emergent forms of housing and living in 21st century Europe. There are two pedagogic goals: one is dealing with architectural content by proposing adequate forms of dwelling for contemporary European societies; the other is dealing with pedagogy by integrating teaching methods and information technologies. However, this Web site lacks interface for exchanging information. It is not convenient for learners to discuss and communicate each other.

WINDS (Web-based Intelligent Design and Tutoring System): Web-based INtelligent Design tutoring System (WINDS) (Specht, M. et al. 2002) is a research project that aims to build a comprehensive virtual university for architectural and engineering design. The researchers developed the ALE (Adaptive Learning Environment) system to integrate the functionality of a complex e-Learning system with adaptive educational hypermedia on the Web. The ALE system produces individualized courseware for students depending on their current state of knowledge, their preferences and learning styles. Therefore, WINDS aims to provide a framework related to curricula design and the production, delivery, and evaluation of educational material in a virtual school for design.

Methodology

Architectural Design Course – Common Problem Solving Methodology.

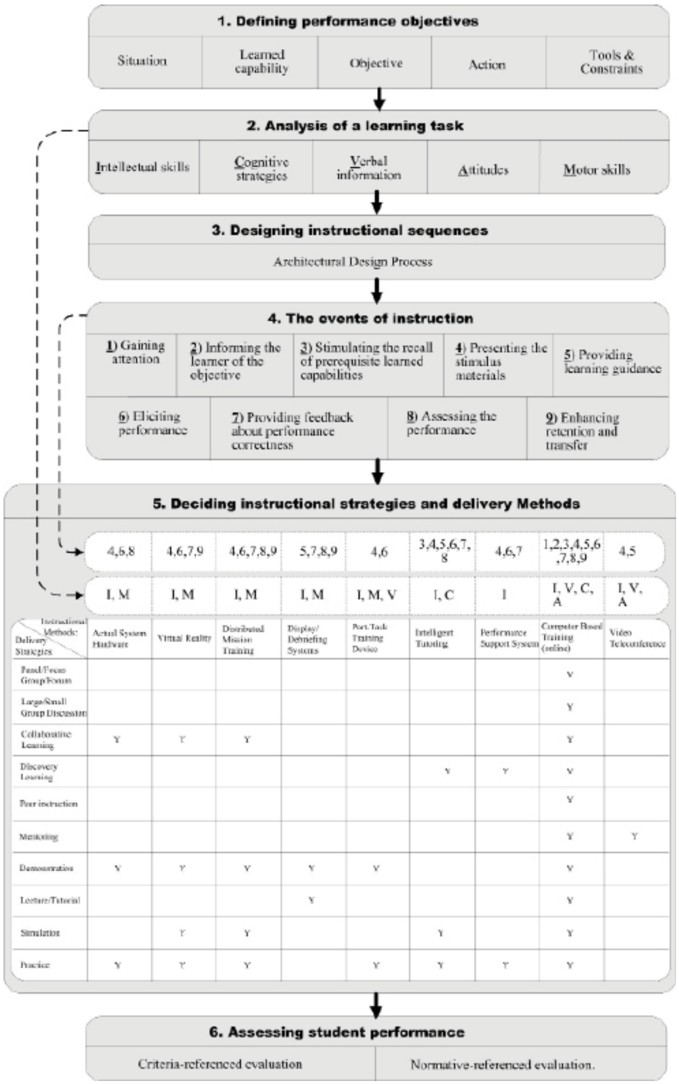
By adopting conventional and general methods of design processes we can define six main phases that are typically employed in architectural design as a problem solving process:

1) Understanding and analyzing the given project program and main requirements and constraints, which is called "problem definition".
2) Analysis phase: Site analysis, environmental studies, study of precedents, socio-cultural context analysis and functional relationships of spaces; that phase usually enhance the problem definition and explore the problem constrains.
3) Synthesis process that involves the physical architectural solution generation; that is usually the most challenging part and has many approaches to achieve a preliminary ideas.
4) Developing a number of alternatives of design concepts.
5) Assessment of alternatives to select the most appropriate solution with regard to the design requirements and predefined criteria; that is usually achieved through assessment for the alternatives based on predefined criteria.
6) Finally, the communication phase, which is the presentation of the solution in a complete set of conventional drawings.

The notion of the suggested model is to provide an educational tool that covers those stages in an adaptive web-based environment.

Overview of General Web-based Educational Model

In Figure 2, we illustrate all the procedures of Web-based teaching and learning in parallel and identify the components of each phase.



Delivery Strategies / Instructional Methods:	Actual System Hardware	Virtual Reality	Distributed Mission Training	Display/ Debriefing Systems	Part-Task Training Device	Intelligent Tutoring	Performance Support System	Computer Based Training (online)	Video Teleconference
	4,6,8	4,6,7,9	4,6,7,8,9	5,7,8,9	4,6	3,4,5,6,7,8	4,6,7	1,2,3,4,5,6,7,8,9	4,5
	I, M	I, M	I, M	I, M	I, M, V	I, C	I	I, V, C, A	I, V, A
Panel/Focus Group/Forum								Y	
Large/Small Group Discussion								Y	
Collaborative Learning	Y	Y	Y					Y	
Discovery Learning						Y	Y	Y	
Peer instruction								Y	
Mentoring								Y	Y
Demonstration	Y	Y	Y	Y	Y			Y	
Lecture/Tutorial				Y				Y	
Simulation		Y	Y			Y		Y	
Practice	Y	Y	Y		Y	Y	Y	Y	

Figure 2: The Procedures and Components of Web-based Educational Model. (Source: Authors).

Adaptive and Intelligent Web-based System for Architectural Design Course

Based on our introduction of the adaptive and intelligent Web-based systems major strategies in the architectural design education are identified and mapped with the adaptive and intelligent system technologies.

Integrating Architectural Design Course and Adaptive Web-based Education Model

As a result, the suggested conceptual framework for adaptive and intelligent Web-based educational model is shown in Figure 3.

The topmost part presents the sequence of the educational process in architectural design course. Each phase is identified and explained by its content and mapped with our educational framework for adaptive and intelligent Web-based model.

Our conceptual framework is consisted of two parts: 1) major strategies in architectural design; 2) adaptive and intelligent Web technologies including curriculum sequencing, intelligent solution analysis, problem solving support, adaptive presentation and adaptive navigation support.

The framework is also supported by three parts of general educational components:

1. Instructional **S**trategies including: **a)** Panel/ Focus Group/Forum, **b)** Large/Small Group Discussion, **c)** Collaborative Learning, d) Peer instruction, **e)** Mentoring, **f)** Demonstration, g) Lecture/Tutorial, **h)** Simulation, i) Practice;
2. Analysis of a Learning **T**ask including **I**ntellectual skill, **C**ognitive strategies, **V**erbal information, **A**ttitudes and **M**otor skills;
3. The **E**vents of instruction including: **1.** gaining attention, **2.** information the learner of the objective, **3.** stimulating recall of prerequisite learned capabilities, **4.** presenting the stimulus material, **5.** providing learning guidance, **6.** eliciting performance, **7.** providing feedback about performance correctness, **8.** assessing the performance, **9.** enhancing retention and transfer.

The bold faces are represented in Figure 3.

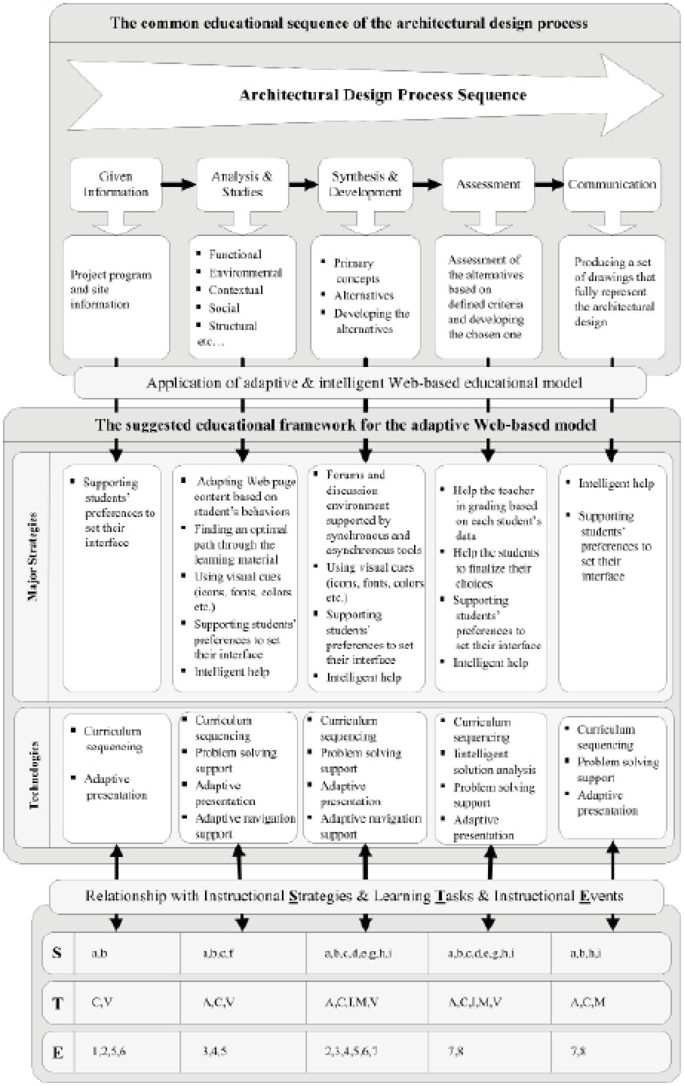


Figure 3: The Learning Process of the Web-based Architectural Design Course. (Source: Authors).

System Implementation

System Architecture

In this project, we build a Dynamic Adaptive web-based model for Architectural Design e-learning environment (DAAD) system to be used as a case study and illustrate the usability of the suggested model. Figure 4 shows the system architecture of the first implementation.

The DAAD system is an on-going project to be implemented by several technologies: PHP scripting language; MySQL, a relational database; Apache web server; HTML; and XML (eXtensible Markup language) technologies. PHP is a scripting language that is especially suited for Web development and can be embedded into HTML, which provides an easy way to build dynamic content. PHP also serves as maintaining sessions (learner browsing behaviors and history) between Web pages and knowledge based stored in the user model. XML allows Web content to be separated from the presentation, where XML is used to store the content.

Prototype Implementation

In Figure 5 through 8, we show several interfaces of our first prototype and illustrate how they work. Figure 5 shows the main interface of DAAD system. The interface of the system can be divided into three main parts: (A) navigation area; (B) tool bar; and (C) content area.

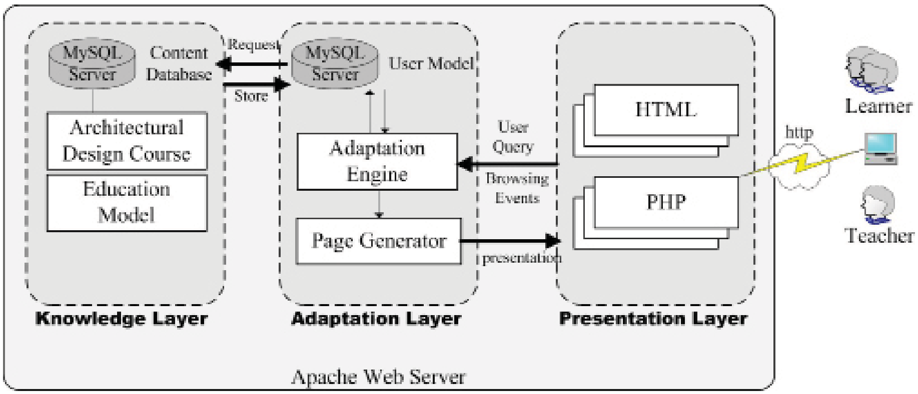


Figure 4: DAAD- System Architecture. (Source: Authors).

Figure 5: Interface of DAAD- System. (Source: Authors).

The interface as mentioned is explained below in more details:

(A) Navigation Area: this area shows the course structure according to the user's goal. Each process is used by visual cues such as colors and icons to show different types of tasks or user progress. The icon is expandable to be shown or hidden to control the information.

(B) Tool Bar: this area includes several modules: "My Model" module contains the user's information to find an optimal path through the precedents and knowledge base; "Preferences" module lets the user choose and adapt his/her own graphical user interface (GUI) (Figure 6); "Communication" module supports embedded synchronous or asynchronous communication tools such as e-mail, video conferencing, shared whiteboard, etc. for users to discuss their ideas (Figure 7); "Mark" module is similar to the bookmark function. If the user marks objects or contents, the system keeps and shows the information to the user when logging in again; "Highlighting" module allows the text on the pages to be highlighted.

(C) Content Area: this area shows the Web course content according to students' behaviors. In other words, each student can see his/her adapted and customized Web pages based on his/her areas of interest or interactions such as searching, bookmarking or setting preferences. The system can also assist the student in navigation by adaptive sort. For example, the Figure 5 shows Frank Lloyd Wright's Fallingwater as one of the topmost frequent visiting cases by students.

A teacher can login as administrator so that he or she is able to see all students' assignments, tasks and their learning progress. The teacher can use the adaptive grading table to give them appropriate feedback based on different assessment criteria (Figure 8). The different assessment criteria would also be useful to students to finalize their decisions.

Figure 6: Adapting GUI based to Learner Preferences. (Source: Authors).

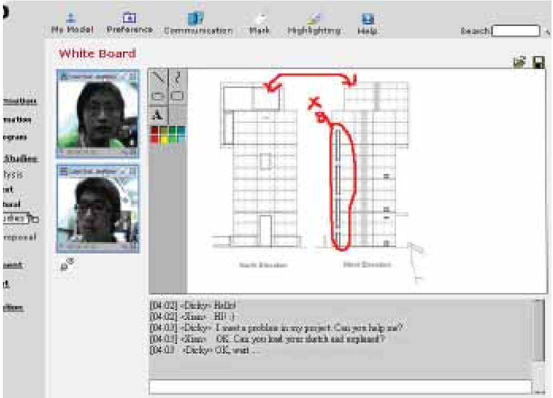


Figure 7: Communication Module (videoconference & white board). (Source: Authors).

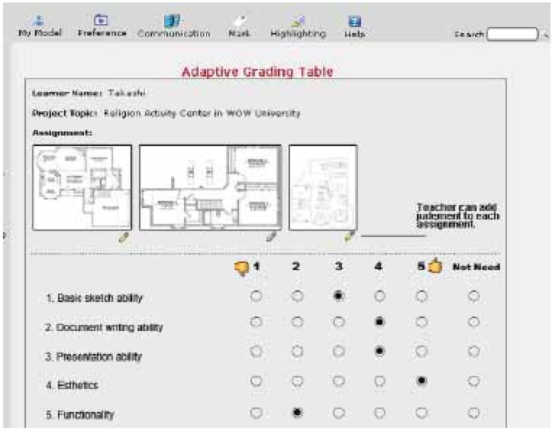


Figure 8: Adaptive Grading Table for Teacher to Different Grading Parameters. (Source: Authors).

Discussions and Conclusion

The suggested model is an ongoing project that has a prototype implementation. The implementation achieved the previously stated goals so far, the model has been designed to cover as much as possible the gaps found in the recently used models (2.5), the goals and achievements of the suggested model are discussed below:

Finding optimal path: When a user sets up the model, the system finds an optimal path through the precedents and knowledge base. In other words, the system can suggest the next design task node based on user's goal stored in the user model. That was possible trough scripting language PHP embedded into HTML, which provides an easy way to build dynamic content and maintain sessions (learner browsing behaviors and history) between Web pages and knowledge stored in the user model.

Link adaptation and recommendation: Each student is able to have his or her unique Web pages according to browsing behaviors and interactions such as searching, bookmarking or highlighting. The system can also assist the student in navigation by adaptive sorting and ranking, or recommend similar examples or links by using the history recording.

Adaptive annotation: The system uses visual cues (colors, icons, fonts) to show different types of tasks or user progress. A checkbox is also useful to verify the tasks completion.

Communication tools support: For an architectural design course, group discussion is essential. The system supports embedded synchronous or asynchronous communication tools, such as: e-mail, chat rooms, video-conferencing, digital whiteboard, virtual gallery, etc. for users to discuss and share their ideas.

Adaptive assessment: A teacher can login as administrator and use the adaptive grading table to give students appropriate feedback based on different assessment criteria. The different assessment criteria would also be useful to students to finalize their decisions.

For future work, the notion is to test our preliminary implementation by applying an empirical study in the preliminary architectural design studio (2 and 3) to test and analyze the efficiency and usability of the suggested model.

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