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Adaptive Educational Hypermedia System

Tamer Elnawawy, Ahmed AbdElnabi, Hany Harb

Abstract **– E-Learning can be viewed as an innovative approach for delivering well designed, learner-centered, interactive, and facilitated learning environment to anyone, anyplace, and anytime. It utilizes the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible, and distributed learning environment (Khan, 2001) [1]-[2]. This paper presents design and implementation of an adaptive educational hypermedia system by using Moodle to provide learners with a customized learning environment. The proposed system models features such as user knowledge, goals, and context of work. The strengths of our Moodle-Based model are the realization of communication tools, and the creation and administration of learning objects. Additional strengths are the comprehensive didactical concepts and the tracking of data. The system has been evaluated and its implementation has been discussed.**

Keywords **– Adaptive Educational Hypermedia Systems, Learning Management Systems, E-Learning, Moodle.**

I. INTRODUCTION

Distance learning has exploited the new methods of communication using the Internet or the intranet to access learning materials and to interact with the content, instructor, and other learners. Millions of students across the world register for online courses and learning programs for taking their courses from their homes at any time. There is also a growing area of mobile learning or "m-Learning" that uses mobile devices (such as mobile telephones and PDAs) [4]. Distance learning is often cheaper and allows greater flexibility in choice of content, convenience and portability. It has many advantages such as simplicity of use, higher interactivity, better knowledge retention, accurate evaluation, self-paced, self-directed learning, self-customized learning, authentic practice , capability to create highly realistic simulations, management of online class transactions; tracking and reporting of learner progress in learning activities; reporting of achievement and completion of learning tasks; and student records management. Teachers can use the Learning Management Systems (LMSs) to develop Web-based courses, to communicate with students, to monitor, and to grade their progress. A few of the widely known LMSs are Moodle, Blackboard, WebCT, Dokeos, ILIAS, ATutor, SAKAI, Caroline, NetCoach, AHA!, Inter Book, and Tangow. All providers of LMSs functionality are developing compliance with the evolving content object standards, like AICC and SCORM [3]. An adaptive educational hypermedia system (AEHS)is an interactive system that personalizes and adapts e-learning contents, pedagogical models, and interactions between participants in the environment using different parameters and a set of pre-defined rules to meet the individual needs, prior knowledge, learning styles, experience and preferences of users if and when they arise [6]. AEHS contains three models: the student model, the domain model and the adaptive model [5]. The domain model (DM) is usually a representation of the course being taught and contains information about workflows, participants, roles, etc. The DM consists of concepts and concept relationships. There are several ways of structuring the DM such as linear/one-dimensional, concept graphs, prerequisite graphs and semantic networks. The user model (UM) saves all information about a particular user; Static part covers user's personal characteristics and user's capabilities which can be collected at the beginning of the learning process, using questionnaires or different tests. Dynamic part is gathered directly from the user through tests, practice or user's actions, which can be collected during the learning process. The three most commonly used methods for representing the UM are overlay model, weighted overlay model, and stereotype model. The system has to update attribute values of the UM by observing user's behavior [7]-[8]. The adaptive model (AM) defines what can be adapted, as well as when and how it is to be adapted [9], [10]. Two distinct types of adaptation are used: presentation and navigation support (Brusilovsky, 2001, De Bra et al., 1999a) [18]-[19]. The adaptive presentation (content level adaptation) refers to the information which is shown to the user. The content of the hypermedia page is dynamically altered and can vary in details, explanation, media use, or number of links. In adaptive text presentation, Text fragments are inserted, removed, altered, sorted or dimmed in order to adapt the content that is shown to the user. Additionally, adaptive multimedia presentation and adaptation of modality techniques deal, respectively, with the selection of (canned or automatic) multimedia fragments and with the selection of different types of media (text, video, audio, etc.) to present the content. The adaptive navigation covers different technologies (e.g. direct guidance, Adaptive link sorting, hiding, annotation and generation), which provide directional assistance to the user [11]. Fig 1 illustrates the techniques of hypermedia adaptation.

II. RELATED WORKS

Tutor is an Open Source Web-based LCMS developed at the Adaptive Technology Resource Centre (ATRC) at University of Toronto and was first released in late 2002 [28]. Tutor has Accessibility features such as: text alternatives for all visual elements, keyboard access to all elements of the program, and content authoring tool that prompts content developers to create accessible learning materials. It also has Adaptability features such as: allowing administrators to easily customize the look and layout of the system to their particular needs, and allows instructors to assign tool management privileges to particular members of a course. It requires the use of PHP which should be configured on HTTP Web Server (Apache recommended) and MySQL database [34].

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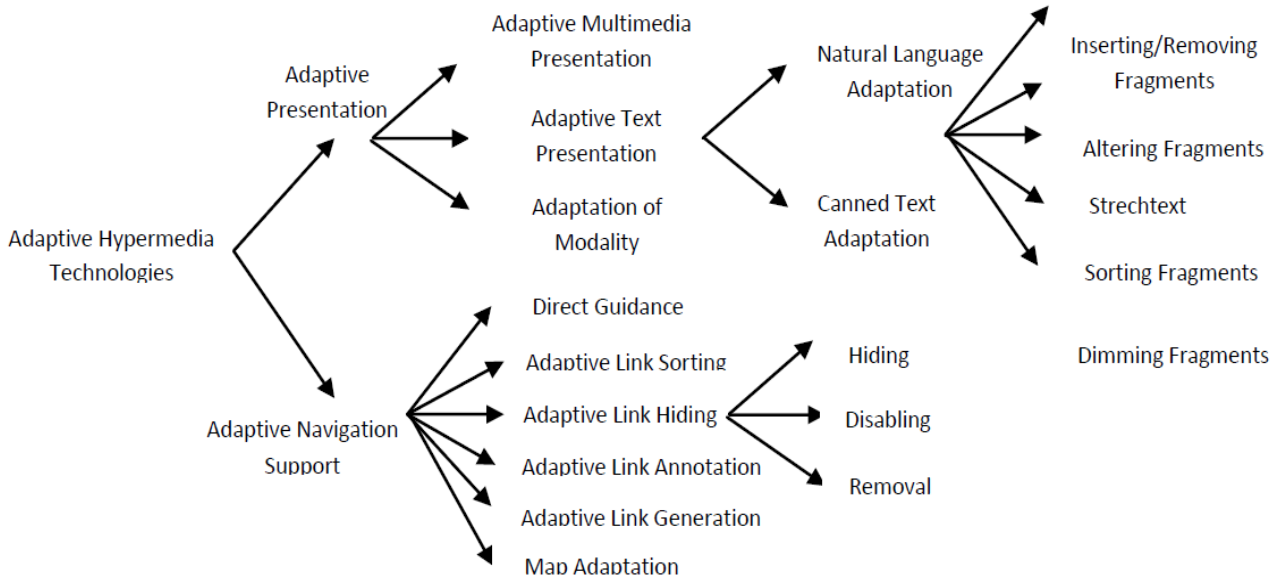

Fig.1. Adaptive hypermedia techniques [19]

The Sakai CLE (Collaboration and Learning Environment): is a free open source software platform developed by a community of academic institutions, commercial organizations and individuals to advance teaching, learning, and research [35]. Sakai has many features: Collaborative research developed tools such as blog tools, shared whiteboard and podcasting functionality. The Domain Independent Data Model consists of 1-generic profile which includes: Personal information, academic background, and qualifications; 2- and psychological profile which includes: Learning style (taxonomy), cognitive capacities, and inheritance of characteristics [12].

Ilias has been developed at the University of Cologne in Germany. It has a modular and object oriented software architecture that allows independent reuse of contents. The system available tools include personal desktop, learning environment with personal annotations, search engine, learning modules, glossaries, digital books, mail, discussion forums, chat groups, and user tracking and reporting. It requires the use of PHP4 which ideally should be configured on Apache server in connection with the SQL database MySQL. The target operating systems are mainly UNIX, Mac OS X or Windows [14]-[29].

Blackboard was developed at Blackboard Inc. in Washington founded in 1997 by Michael Chasen and Matthew Pittinsky [12]-[34]. Many tools are available and can be customized by the lecturer's/instructor's preference such as: announcements (allows creating a notice board for students, which is easily updated), communication (Discussion board, chat room and E-mail), and assessment (online tests and surveys can be made quickly and securely). It also provides digital drop-Box tool which allows students to securely send files or assignments to instructors/tutors and the test tool which enables students to self-assess their learning and monitor their progress, as well as allowing instructors to provide feedback. Blackboard is available for Windows, Solaris, Linux, and SQL Server Enterprise Edition [30]-[31].

TANGOW is a tool for developing Internet-based courses [36]. It contains three main components: the process manager, task manager, and the page generator. The process manager is a server which launches a student process and transfers the student requests to the task manager. The task manager receives information from the process manager to select the appropriate teaching tasks and to provide the page generator with the parameters that will be needed during dynamic page generation. The page generator builds the HTML pages presented to the student [15].A course is described in terms of Teaching Tasks (TTs) and Rules which may be atomic or composed. TTs may be theoretical, practical or a set of examples. In addition, a TT may have a list of media associated elements (text, images, videos, applets, sounds, animations). A rule describes how a TT is divided into subtasks. Student data model contains attributes such as preferred language, age, and learning styles. These attributes is taken from an e-questionnaire. TANGOW provides an adaptive presentation using fragment variant technique and it also supports adaptive navigation using adaptive link annotation and direct guidance techniques [16].

NetCoach is promoted by WESTBIC Business Management Centre with the support of Learnado Da Vinci Lifelong Learning Program [37]. It is based on a LISP-server (CL-HTTP2)/ web-browser client technology and it is available for Windows, Apple, and Linux operating systems. It adapts to three aspects of the user: knowledge, goals, and preferences and it supports multiple languages. The domain model of NetCoach represents the knowledge base of a course which consists of concepts or pages and relations. There are two relations between concepts: prerequisites and inferences. The student model is a multi-layered overlay model. NetCoach supports both the adaptive annotation of links and individual curriculum sequencing but it doesn't provide adaptive presentation [13].

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III. The AEHSM Model: Adaptive Educational Hypermedia System for Moodle

The proposed model aims to achieve different objectives. It offers an authoring tool that helps the administrator and the teacher to develop adaptive learning courses and quizzes over the webpages according to pre-defines rules and attributes such as user experience, prior-knowledge, interests, learning goals, pedagogical experience, mathematical knowledge, and skills. This adaptation allows the student to access the most appropriate, interesting and challenging learning activities. The model also facilitates information sharing and communication between participants in the course and it also manages distance classes and enables collaborative learning with forums, chats, file storage areas, news services. The model architecture is composed of three main components: User Model, Domain Model, and Adaptation Model. It is based on the Moodle [17].

A. The User Model (UM)

This component is mainly concerned of the user (student) aspects where it keeps track many student affairs and activities in the associated database. The Moodle provides a database which has been used for the following functions:

- Storing all the system's information and user static information (Domain Independent data) such as personal information, preferences, prior-knowledge, experience...etc.
- Storing all the dynamic information about the user (Domain dependent data) such as: Learning Tasks, objectives, interests, learning mode, Difficulty, linguistic requirements, mathematical-logical requirements, perspective, interactivity...etc.
- Updating the academic results, user's interaction data, and dynamic information by the updating module.
- Keeping detailed logs of all activities and actions that students perform not only as log files but also directly in databases, also keeping track of what materials students have accessed to determine who have been active in the course, what they did, and when they did it.
- Keeping detailed analysis of the student responses and item analysis such as the item last access, and number of times the item read.

The following screenshot illustrates the design of Moodle Database schema by using phpMyAdmin:

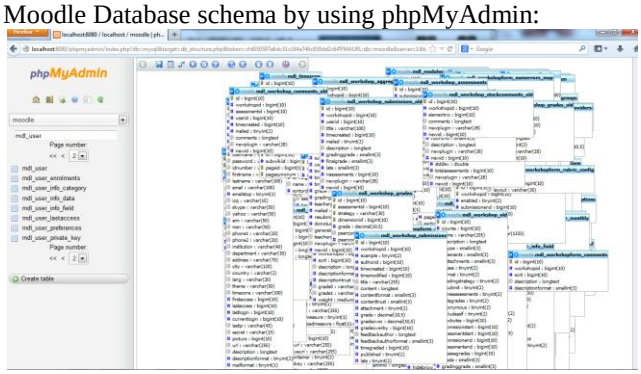

Fig.2. Moodle Database Schema

The architecture of the UM is shown in fig. 3 which illustrates the two main components of UM: the updating module, and the data storage.

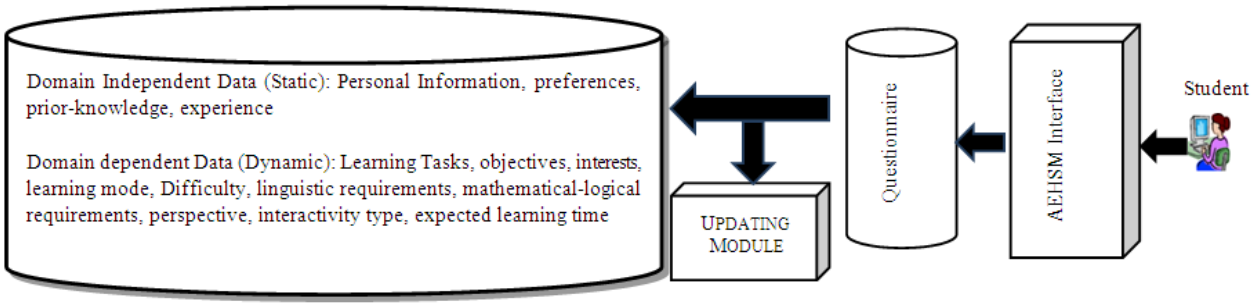

Fig. 3 Architecture of the User Model

B. Domain Model (DM):

This component is mainly concerned of the course materials such as courses, lessons, assignments and other user activities. Constructing AEHSM courses requires building course hierarchy and quizzes.

Building Course hierarchy: To build a course, the teacher can use course editor and define some course attributes such as Category, full name and short name, id number, summary, format, and start date. He can add activities to the course such as: lessons, assignments, glossaries, surveys, wikis, and workshops and can add resources such as books, files, and web pages. Figure 4 demonstrates a course overview. Building quizzes: At the end of each concept, a quiz is presented to the student to measure his/her grasping level.

Fig. 4: AEHSM Courses overview

The architecture of the Domain Model is shown in fig. 5.

C. Adaptation Model (AM)

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For defining adaptive rules, teachers could use an expression-builder tool which is based on the definition of adaptive statements: IF <condition> THEN <action>. The adaptive rules may include learning design elements, personalization properties, and logical and relational operators (Berlanga & García, 2004) [20], see tableI.

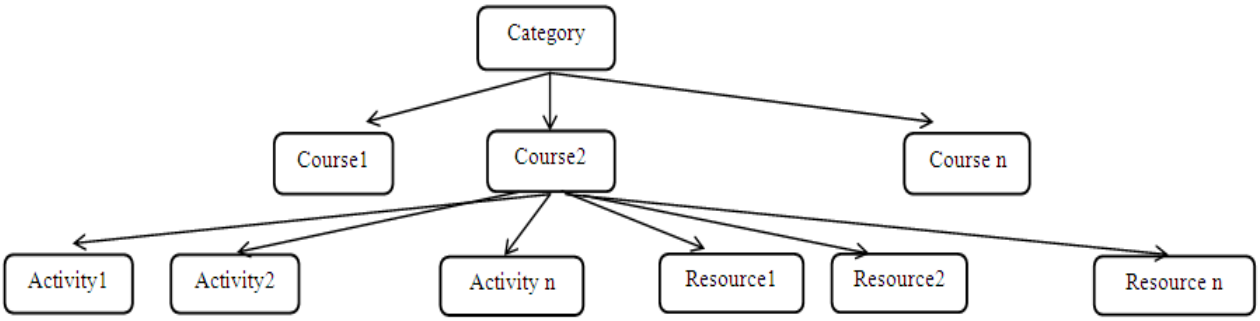

Fig.5. Architecture of the Domain Model

Table I: Collection of sets to describe adaptive statements (Merrill, 2002) [21].

Set	Sub-set	Elements/Data/Operators/Actions/
element-set	learning-design-structure	Prerequisite; Learning-objective; Learning-activities Activity-sequence; Support-activity
	student-element-set	Student
data-set	student-data-set	Initial-knowledge; Current-knowledge; Final-knowledge; Learning-style
	attributes-data-set	Completed; Visited; Recommend; Sequence; Selection
	time-data-set	Time-unit-of-learning-started; Date-time-activity-started
logic-operators-set	binary-op-set	And; Or
	unitary-op-set	Not
relational-operator-set	relational-op-set	Greater-than; Less-than; Equal; Greater-or-equal-than; Less-or-equal-than
action-set		Show; Hide; Show-menu; Hide-menu; Sort-ascending; Sort-descending; Number-to-select

For instance, teachers could create an adaptive statement that establishes that if the initial knowledge of the student is equal to 5 and his learning style is “novice”, then the learning activity for novices will be shown. IF <student>: (initial-knowledge, equal, 5) and (learning-style, equal, “novice”) THEN show (learning-activity-introduction-novices).

The architecture of the DM including its relations with our proposed AEHSM components is shown in fig. 6:

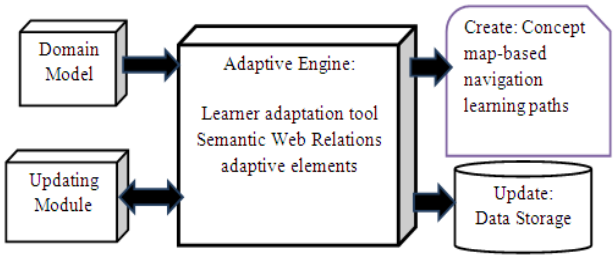

Fig.6. Architecture of the Domain Model

IV. The Implementation

The AEHSM model is developed using the following tools: Moodle 2.4.6+, MySQL 5.1.33, Xampp1.7.7, Appache server 2.2.21, PHP 5.3.8, ispring6 free, quiz maker 6.2.0, ispring presenter 7, Adobe CS5 Flash, and Microsoft PowerPoint 2010. The next section presents the main features of Moodle which is the main model development tool.

A. The Moodle architecture

Moodle is a free learning management system created by Martin Dougiamas and made available for general release in August 2002 [12].It allows creating powerful, flexible, and engaging online web pages include courses, images, videos, glossaries, animations, quizzes, assignments, chatting rooms, forums and full of different kinds of student-to-student and student-to-teacher interaction [17]. The word Moodle was originally an acronym for Modular Object-Oriented Dynamic Learning Environment. Moodle needs web hosting service and it needs to have an account on the web server to be uploaded on. For the memory, 1GB of RAM on the server can serve 50 simultaneous users. To install Moodle 2.4, minimum prerequisites must be offered on the web server such as PHP 5.3.2, Databases (may be MySQL 5.0.25, PostgreSQL 8.3, Oracle 10.2, or MS SQL Server 2005) and standards-supporting browser (may be Firefox 3, Safari 3, Google Chrome 4, Opera 9, or MS Internet Explorer 7)[24]-[25]. The basic AEHSM features are presented as it follows [24]-[25]-[32]:

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- *Configuring users' authentication methods* such as Manual accounts which enable the administrator only to create user accounts, No login which enables the administrator to suspend a user's account, Enabling e-mail-based self-registration which enables people to register themselves for the site, Bulk uploading and updating users by using CSV file, or Authenticating against an external source by connecting to another database servers or Web services authentication.
- *Granting access to courses with enrolment* choices such as Manual enrolment which is the default form of enrolment that enables a teacher or administrator to enroll the user to a role (manager**,** teacher, student or non-editing teacher.), Guest access which grants guests access to courses, Self-enrolment which allows users to enrol themselves in courses, and other choices as PayPal, LDAP, External database, or IMS Enterprise file.
- *Creating Categories and Courses***:** A course always belongs to a single category which acts as courses container. The course can be configured as Topics, Weekly, Social, or SCORM. Students may be forced to complete activities in a specific order. Students can view a list of all of their grades for the course. Each course can have either no groups or several groups. If the group mode is not applied, all students assigned to the course are considered to be in one group, so they can see each other's work.

AEHSM may have multiple types of interactive course materials such as lessons, assignments, and quizzes. When the student completes the assignment, he either uploads a file for the instructor's review or reports to the instructor in some other way. The student receives a grade for the assignment. Lesson is a series of web pages where the next page displayed might depend upon the student's answer to a question. AEHSM offers a flexible quiz builder containing questions which are considered as a full-featured web page that can include any valid HTML code to enable texts, images, sound, and movies and anything else that can be put on the web page. The Question Bank is collection of quiz questions. Administrator, or the teacher has a full control to identify the period of quizzes availability, identify a time limit of submitting the answers, limit the number of times that a student can take the quiz, subtract a penalty from the quiz score for a wrong answer, set password to access the quiz, restrict access to the quiz to particular IP, and create several kinds of feedback for quiz such as general or overall feedback.

AEHSM has multiple kinds of module activities such as chat, forum, glossary, and workshop. The Chat module creates a chat room where students can have real-time to collaborate on work and exchange information. When Chat is schedule, it appears on the course Calendar and is also displayed in the Upcoming events block. The students can enter chat room at any time. It is possible to show the past chats to anyone or restrict that to the teachers only. A well-run class forum can stimulate thoughtful discussion, motivate students to become involved, and result in unexpected insights. There is a possibility to create a Forum that only Teachers can access to collaborate on a course. A Glossary is a list of words and definitions (linked to a course) that can be accessed to users who browse the course. The Wiki module allows students to collaborate on a group writing project, build a knowledge base, discuss class topics, and encourages collaboration among the participants. Workshop is a powerful collaborative grading tool where it provides a place for the students in a class to see an example project, upload their individual projects, and see and assess each other's projects.

Furthermore, AEHSM has other multiple tools and features such as reports, statistics, backup and restore, and language options. AEHSM records detailed logs of each action and activity performed by a user such as, who did (user), what (action), When (date and time), and Where (IP address). AEHSM offers a Statistics mode, which provides a graphical summary about the number of hits in courses and the entire site. Students' progress through a course can be determined. AEHSM displays the log files which can be filtered by course, participant, day, activity, and action. Statistics are recorded by the web server and displayed using a statistics analyzer and graphs in order to track the usage of the website. AEHSM offers the ability to select the type of data that gets backed up as well as configuring a schedule which the backup can run automatically. The course backups can be restored anytime. The default Moodle installation includes more than 40 language packs.

B. The Implementation tasks Installing Web servers and Moodle:

At First, A web-hosting server is built on our machine by installing XAMPP from http://www.apachefriends.org; which is an easy and all-in-one installer that installs Apache, MySQL, PHP, and Perl. It is available for Linux, Windows, Mac, and Solaris. Then, Moodle can be downloaded as a single compressed file from the official website http://www.moodle.org/. We set the Moodle directory as: C:\xampp\htdocs\azhar, this directory contains a script called install.php that creates the tables of the database, and Moodle configuration file config.php which stores all configuration variables. During the installation, a web address for accessing Moodle can be set as http://localhost/azhar as well as both a directory path to this installation and a place where Moodle can save uploaded files. Also, the database driver can be determined as Improved MySQL (native/MySQL) which is highly recommended.

Reconstructing and customizing the Moodle website: The front-page was edited. Arabic language pack was also installed at our site. Fig. 7 displays our AEHSM web-site homepage. If a new student is logged in, he will have two options: the first one is to sign up by where the system presents a registration form in which the personal information is filled as shown in Fig. 8 to then be confirmed by administrator; the second option is to log in as a guest with the a guest privileges which set by the administrator as well. But if the user is an old one, he can log in to the system with his username and password as shown in Fig. 9.

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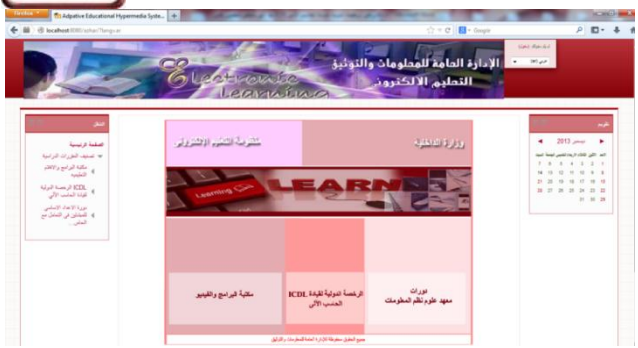

Fig.7. AEHSM Homepage

Fig.8. AEHSM Student's Registration Form

Fig.9. AEHSM User login form

Creating courses: When the manager of the system logs in AEHSM, he can create easily any course. It is recommended to choose the SCORM formatting as shown in Fig. 10. To generate SCORM compliant course, ispring 6 free program and ispring presenter7 program are used to publish the courses into our website as shown in Fig. 11. Then, the users can be enrolled in this course.

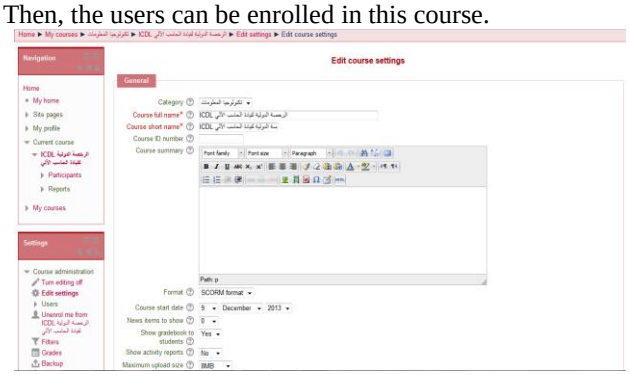

Fig.10. Creating and editing courses in AEHSM

Building quizzes: The quiz tools enable the teacher to create the questions bank and build quizzes by using quiz maker program as shown in Fig. 12.

Fig.11. ispring 6 free

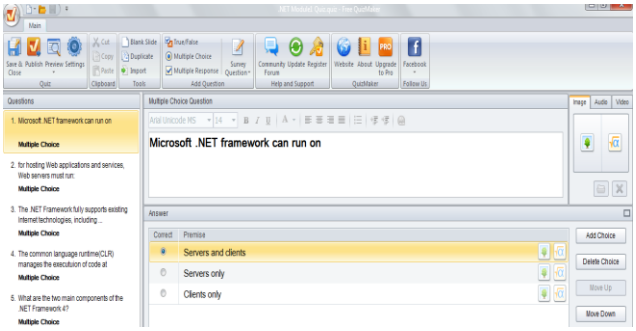

Fig.12. free quiz maker 6.2.0

The quiz maker program offers the teachers many features such as setting the point of the question, setting the passing score of the quiz; normalizing the score to any wanted number, enabling time limit of both question and quiz, displaying cumulative score with each question, displaying question point value and actual points awarded, and etc. After publishing the quiz, it can be displayed at the end of the course. The quiz results can be displayed as shown in Fig. 13.

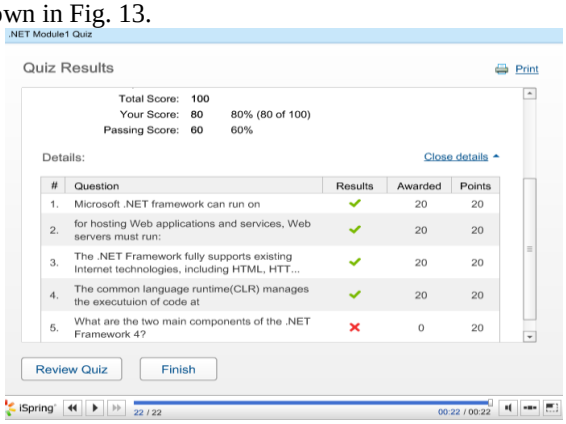

Fig.13. Visual basic .Net Quiz Result

Building the Adaptive Courses: DASIS (Dynamic Addressee Specific Information System) package supports students in making their individual way through hypermedia learning contents [26]. DASIS has features such as concept map-based navigation between courses, direct guidance navigation with learning paths, and adaptive navigation support. It contains three essential blocks: Navigation Web, Learner Preferences, and Learner

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Adaptation [33]. Semantic Web is necessary for interdisciplinary navigation and works without adaptation but can be enhanced with adaptive navigation support. Adaptation is realized by the blocks Learner Adaptation and Learner Preferences. Adaptation Settings: The adaptive global settings can be used for every adaptive course of our Moodle platform which can be arranged from Site administration/Plugins/Blocks/Learner adaptation.

Concept Map Settings: The settings of the concept map can differ for every course that contains a Navigation Web block. The navigation web settings should be as shown in the Fig. 14.

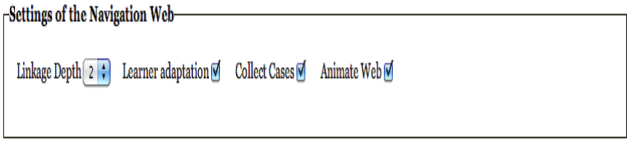

Fig.14. Navigation web settings

A great advantage of AEHSM with installing DASIS is the possibility to navigate interdisciplinary between different courses. These courses are managed with course bundles. One bundle can contain several courses. The use of bundles ensures that only the desired learning activity connections are shown in the concept map and not all known connections of the whole Moodle platform. To create and provide learning paths, we defined a course bundle that contains the proposed path, the name, color, and description of the path. This information will appear in the concept map and direct guidance controls. Finally we can add the nodes (learning activities) to the path of a predefined order.

Metadata of Learning Objects: from Navigation Web block/ Edit Metadata, "semantic relations" of the learning objects have to be set; otherwise concept map for navigation could not be generated. "Short name" of learning objects are recommended. “Description”, “Keywords”, “Learning Tasks”, and “Taxonomy” are currently not necessary to execute case based reasoning or to draw the concept map. The remaining metadata such as "Difficulty", "linguistic requirements", "mathematical-logical requirements", "learning mode", "content" ,"organization" , "perspective" ," interactivity type", and "expected learning time "are optional but the more we fill in the more precise the learner adaptation can work.

C. The learner Tasks

Learners can describe themselves with metadata stored in the UM which can be edited from "Learner Preferences"/“Modify learner preferences. The more attributes are specified the more precise are the results of case-based reasoning. The course navigation can with or without adaptive support. If the adaptation is turned off, the learner can use the concept map or learning path navigation. Both these navigation types are included into the block Navigation Web. Learners can navigate along the chosen learning path. To open the concept map, the learner has to click on the mini map of the block as shown in Figure 15. In this map, nodes represent the learning activities and their semantic relations which are visualized as links between the nodes. Learning paths are drawn as colored links and the already visited learning activities show a check mark.

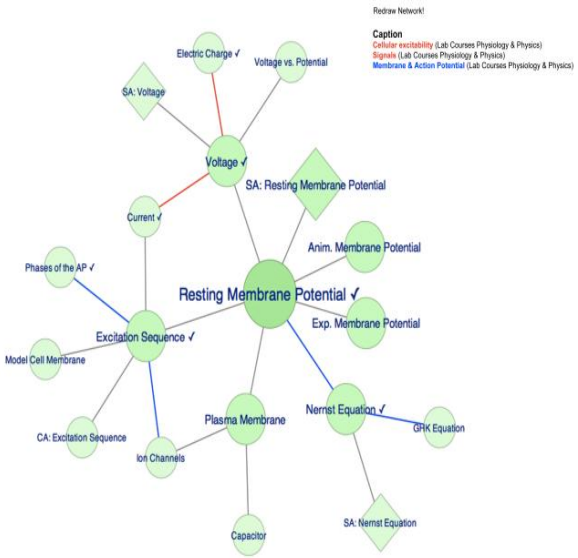

Fig.15. dynamically generated concept map

If adaptation is turned on, there are two more features than with non-adaptive navigation. First, the learner can choose to walk along an adaptive path which means that a click on the next button brings her to the individual calculated best next learning activity. Second, the nodes of the concept map are colored in traffic light metaphor to denote which learning activities are suited well to her current navigation problem. If there is not enough information about the suitability of one learning activity, the node is colored grey.

D. The Model Evaluation

A comparison among our Moodle-Based model and other eight open source platforms are displayed, see table ii [27]. It can be seen that the model achieved the best evaluation values. The model can be extended in a way that the courses adapt to the unique strengths, learning objectives, knowledge levels, and learning styles of each individual learner.

V. CONCLUSIONS

The paper aims to find out how to design adaptive educational hypermedia system by using Moodle to provide learners with a customized learning environment. Adaptive Web systems have investigated a range of approaches to user modeling, exploring how to organize the storage for user information, how to populate it with user data, and how to maintain the current state of the user. The most popular features modeled and used by adaptive Web systems are user knowledge, interests, goals, background, individual traits, and context of work. The strengths of our Moodle-Based model are the realization of communication tools, and the creation and administration of learning objects. Additional strengths of the proposed model are the comprehensive didactical concepts and also the tracking of data. The proposed system has shown good evaluation results compared to other systems.

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Table II: Evaluation Results of E-Learning Platforms for each Subcategory

<table>
<tr><th>Subcategories</th><th>Forum
Chat
Mail\Messages
Announcements</th><th>Tests
Learning material
Exercises</th><th>Tracking
Statistics</th><th>User-friendliness
Support</th><th>Adaptability
Personalization</th><th>Standards
System Requirements</th><th>User Management
Authorization management</th><th>Administration of courses
Assessment of tests</th></tr>
<tr><td>Maximum values</td><td>* * | + + + *</td><td>* * # + *</td><td>* + + #</td><td># # + +</td><td>* # * *</td><td># + * +</td><td># * |</td><td>+ # #</td></tr>
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