A Generic Model of Student-Based Adaptive Intelligent Web-Based Learning Environment

Nedhal A. M. Al Saiyd, and Intisar A. M. Al-Sayed

***Abstract*—Intelligent e-learning systems intend to improve the quality of e-learning services and overcome the main shortcomings of e-learning technologies that presented the same learning material to all learners; "one-size fits-all" approach. In this paper, the suitable architectural design is proposed and the development modules of intelligent, adapted student-centered Web-based e-learning system are explained. It addresses students' diversity with different intellectual levels, different learning styles, so as to improve the learnt concepts and support the learners to achieve their learning goals effectively. The course contents are adapted and tailored to the characteristics of each learner. Each student has to answer two sets of well-selected tests to determine his background knowledge. These tests are randomly generated via an adapted rule-based reasoning engine utilizing questions repository and student and domain modules. Furthermore, the system will remember the last three sessions of the learning process for each student, even it is not completed, henceforward; the student can accomplish learning process from his last session. According to the experimental results, most of the students recommended to use it. Students were satisfied with the intelligent Web-based learning environment regarding the usefulness and efficiency. It helps to improve students' knowledge level and academic progress.**

Index Terms*— *Adaptive Learning System, Blended Learning, Intelligent E-Learning System, Pedagogical Module, Web-Based Learning

I. INTRODUCTION

Blended learning is the learning paradigm combines the traditional and distance learning, adopted in almost all higher education learning institutions. For decades, it has moved through a number of generations and the development of education models has taken advantage of new technologies as they approached to hand [1, 2, 3]. Distance learning involves the active contribution of the learner in a variety of knowledge-learning and training activities. It is to provide e-learning anywhere, anytime and on any device to improve student's learning experience [4]. E-learning is considered as more than knowledge acquisition. [5].

Even the high growth of e-learning platforms technologies implies increasingly dynamic and different Web-based learning infrastructures; blended learning model paradigm faces many challenges. These challenges are mainly pedagogical. They did not take into consideration pedagogically or intellectually student characteristics of the learning process [6]. Moreover, most of recent blended e-learning systems provide all students with the same educational inputs that are not altered to encounter students' individualities. All students have access to similar learning resources and therefore need a lot of time up until reaching their learning goals that are well-matched with their background knowledge. The instructional materials are designed as fixed learning paths through the curriculum because it is critical to automate the instructor's role in online training [7]. These problems are not caused by the technology. These aspects need to be managed to develop more efficient, effective system that present new type of services and mechanisms. Therefore, different types of requirements and services, such as personalization and adaptation, are imposed to satisfy the needs of intelligent learning systems (ILS) [8].

There are a range of learners who are not included into many education systems because they have a disability or special needs which current education systems are not addressing. The universal design of learning systems which meet the needs of everyone is close to impossible. However the increased use of the internet and the modern technologies for people with disabilities make the concept of inclusive design more practical [9]. Learners are different in their various learning abilities, needs, methods and preferences. These differences should be taken into account when planning a learning process. To reduce the gap between traditional educational techniques and future trends in blended education; new techniques are needed to apply. Toward this goal, various e-learning systems are developed. Most of them lack educational multimedia content or personalized support in dynamic learning [10]. Developing inclusive learning solutions is considered as a complicated area of research and practical work [4].

In student-centered learning environments, learners are expected to build their knowledge with the help of their teachers, peers, and/or with the help of computer-based learning systems [11]. It is difficult to adapt a learning process for an individual where the teaching takes place in large classes and among a large number of students.

The success of any e-learning system depends on the retrieval of relevant learning materials according to the requirement of the learner and to deliver contents in a customized and adaptive manner. This leads to the

Manuscript received March 09, 2013

Dr. Nedhal A. M. Al Saiyd, Associate Prof., Computer Science Dept. Faculty of Information Technology, Applied Science University, Amman-Jordan; e-mail: Nedhal_alsaiyd@asu.edu.jo.
Dr. Intisar A. M. Al-Sayed, Associate Prof., Software Engineering Department, College of Information Technology, Al-Isra University, Amman-Jordan; e-mail: Intisar@ipi.edu.jo.

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

development of the adaptive e-learning system to provide learning materials considering the requirements and understanding capability of the learner [12]. Numerous content adaptation approaches are proposed and significant amounts of research have been performed. The approaches include [13]:

i. Static adaptation approach, which defines, describes and stores multiple versions of the content. It reduces the time of downloading the course materials but it requests pre-processing tasks.
ii. Dynamic adaptation approach, which customizes the content in real-time during the user's request. It needs analysis of course structure.
iii. Context-based adaptation, which consider both the environmental context and the student's preference, for more adapted content.

The utilization of Artificial Intelligence (AI) techniques and methods enable the computer programs and software applications to think and act intelligently, and can create realistic environments. The intelligent e-learning systems are used to customize instructions according to the student's needs and can bring personalized, adaptive, and intelligent services to both students and educators. Most of the successful applications of AI in e-learning systems have not yet been implemented in commonly used e-learning systems [1].

The main objective of intelligent e-learning environments is to improve students' learning process by giving more advanced educational techniques [14], so intelligent learning environments are based on different pedagogical approaches and theories that have been developed in the education field [15]. Lessons are highly structured and are largely extend under automated control. Within this framework, the intelligence of the system often appears in the form of adaptive sequencing of the course material that is guided adaptively. All of these methods work in well-structured domains, and strongly depend on a fixed collection of pre-processed course materials [16].

The e-learning era opened the door to intelligent tutoring systems (also called intelligent E-learning systems or simply (ITS)), as shown in figure 1. ITSs are used in modern educational approaches and systems because they are more effective learning tools than traditional instruction. Various learning methods are applied to perform the assumptions to adjust a learning process for individual learners. ITS applies artificial intelligence techniques to develop educational systems that are able to adapt dynamically to the learning evolution and have the flexibility to present the teaching materials in responding to students needs. These systems achieve their "intelligence" by representing pedagogical decisions about how to reach the information about learner [17]. These systems allow personalized learning methods, such as providing a personalized learning path in each step of a learning process, offering adaptive tests suitable for a student's knowledge level, or adapting the learning environment to a user's preferences [18].

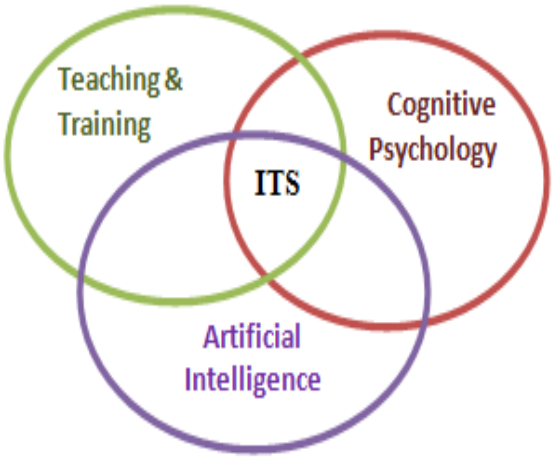

Fig.1: Intelligent Tutoring System [17]

In most intelligent learning system the searching for and the selection of learning objects are based on a set of generic and domain-independent teaching rules according to the learning preferences of the learners. The nominated learning items are presented in an optimized order, where the optimization criteria take into consideration the learner's background and performance. The adaptive course sequencing is defined as the process that selects learning objects from a digital repository and sequences them in a way that is appropriate for the targeted learning community or individuals. Learning object selection and sequencing are considered as among the most interesting research questions in intelligent Web-based education objects [19].

The paper is structured as follows: in section1, we reviewed the current approaches to implement the personalized intelligent e-learning systems. In section 2, we proposed the main components of the architecture of adaptive intelligent learning system. The structure of course material adaptation using rule-based methods is discussed in section 3 and evaluated in section 4. And finally, the conclusions are summarized in section 5.

II. A FRAMEWORK ARCHITECTURE OF ADAPTIVE INTELLIGENT LEARNING

Students are different in their abilities, needs, interests, preferences and in using various learning styles. These variances should be taken into consideration when designing intelligent learning process. In this section, our proposed framework structure of the intelligent student-centered e-learning system is presented, as depicted in figure 2. The learner needs are considered as a prerequisite or inputs to the design that involves learner's ideas and feedback. It is the centre of the design process to develop a system that is able to understand the needs, skills and motivations of learners. The learners who we are targeting are those of higher education institutes who studied 'HTML' course and cannot always have a time to attend the class rooms. The architecture for the system consists of five main modules, where each module is responsible for different functions and activities. These main modules are:

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

A. **The Student Module (Knowledge of Learners):** comprises the student's individual data as account number, password, name, email, major; and related data that are extracted directly from the student. Student cognitive characteristics and prior knowledge that can identify the presentation of specific lecture or topic is obtained indirectly through the answers of tests. The data of incomplete session is stored in 'Student Session' as a historical student's interaction, to be completed later in next session, as shown in figure 3. This module evaluates each learner's performance through sets of randomly generated multiple choice questions (MCQs) to adjust the order of the course material. The more challenging MCQs sets are designated after the student passes the less difficult MCQs. The answers are used to calculate the scores of each level of complexity. The specific information of each individual learner is stored in the 'Student Session' File.

B. **The Pedagogical Module (The Knowledge of Teaching Strategies):** The teaching strategies have a significant effect on learning outcomes. The various teaching strategies are represented**,** where the appropriate selecting and sequencing of the teaching strategies from a digital repository are adapted according to the learners' profile to control the learning session. It permits the individuals accessing the online learning, providing feedback, and managing their time at various performance levels. The pedagogical module is intended for setting the principles of content selection and teaching preparation. The selection of content is based on a set of teaching rules according to the cognitive method or learning preferences. The learning material is divided into sections and displayed in a table of content according to the syllabus. The lectures of relevant course materials are presented in one integrated learning environment. The lectures; include audio, video-based lectures, power point slides, or complementary information (e.g., external links), help students with knowledge acquisition.

C. **The Domain Knowledge Module:** The structured knowledge of course materials with the metadata specifications that covers the 'HTML' lectures. The knowledge represented in this module is used to determine what e-lectures will be displayed to the student and how to evaluate the student answers to conclude the student's knowledge. It stores the lecture name, sequence of the lectures, prerequisite of the lectures, the goal of the lecture and different media forms for the lectures. The domain module interacts with other components to adapt the domain model to the user characteristics to improve the student's style.

D. **The Intelligent Reasoning Model (Problem-Solving Rules):** It consists of the rule-based reasoning methods that personalized course materials. The course material is dynamically adapted to fit student real-time needs, where recording the student's interaction data with the system can provide more accurate data regarding the student's background knowledge and his learning style. The course materials and the knowledge base are searched for the learning objects and select the required or the recommended learning item for the active learners. The rule-base methods (in the form of if-then-else) are for:

   i. **Adapting Course Materials:** combine course sequencing techniques. The adaptive material contents are presented following randomized, adapted and well-selected tests. The system recommends the learning object to the student based on earlier behavior and the testing scores. These tests are generated by the system using a database of questions using student and domain modules that are manipulated via intelligent reasoning engine.
   ii. **Adapting Learning Resources:** adjust the course material according to the learner's domain performance and the requirements of the learning environment.

E. **The Interaction Module:** The interactive learning process can be supported by a variety of screen layouts, which are controlled by the interface model. The lectures associated with an online course are presented in an optimized order.

The detailed design of the suggested intelligent student-centred e-learning system is represented by object-oriented modelling. This design model enables the implementation of loosely-coupled processes. The object-oriented class diagram is derived from framework design to show the static structure of the system being modeled. The model consists of the important classes, attributes, operations, and the interfaces that show how the classes interact with each other. It is depicted as a UML class diagram shown in figure 3. The class diagram is easily translated into programming language.

III. INHERITED ADAPTIVE OBJECT-ORIENTED STRUCTURE OF THE COURSE MATERIALS

To identify the learning strategies that are helpful for effective knowledge acquisition, the course materials are to be collected and analyzed. Declarative and procedural knowledge, skills-based experience and expertise through learning are needed to be structured in a way that allow interacting and support classification, comparison, acquiring and reasoning, as it is shown in figure 4. Explicit knowledge is a prerequisite for assessment and comparison, thus, the choice the appropriate content elements in e-learning system. The intelligent reasoning technique uses the rule-based domain knowledge, course materials and the adaptive lecture object.

The table of contents, the learner's tests answering, and the navigation through personalized learning paths and steps are saved in files. These files are used to build a student profile by identifying the learner's behavior and the knowledge background. A number of well-defined questions that are relevant to a certain topic are stored in MCQs data base, and the questions are combined into groups. The list of questions is randomly generated and displayed to the student after selecting a topic and lecture name. Each student has one attempt to choose the correct answer within a limited time. The system will evaluate the answers and calculate a score that identify if the system displayed the required lecture or customizing the learning object and recommend displaying another lecture that enhances his knowledge before displaying the required one, as shown in the following algorithm:

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Depending on the student's request, the System Search the 'Topic' related 'Questions' Repository of lessComplex_Tests is Generated Randomly
Display Level1_Questions, one by one
Read the Answer
Evaluate StudentBackgroundKnowledgeLevel Save ResultData in StudentSession Data
If CorrectQuestions = 2 out of 3 Questions Then
Display PassMsg
The System Searches the 'Topic' related 'Questions' Repository of MoreComplex Tests is Generated Randomly
Display Level2_Questions
Else
Display FailMsg
The System Searches the 'Topic' related 'Lectures' Repository is well-selected
Display RecommendedLevel1_LectureObject
If level-1_LectureObject is Completed Then
Display Level1_Post_LectureObject_Question
Evaluate Level1_Post LectureObject_Questions
Save ResultData in StudentSession Data
If Level-2_Questions = 2 out of 3Questions Then
The System Searches the 'Topic' related 'Lectures' Repository is well-selected
Display RecommendedLevel3_LectureObject
Else
The System Searches the 'Topic' related 'Lectures' Repository is well-selected
Display RecommendedLevel2_LectureObject
The System Searches the 'Topic' related 'Questions' Repository of MoreComplex Tests is Generated Randomly
Display Level2_Post_LectureObject_Questions
Re-Evaluate level2_LectureObject_Questions
Save ResultData in StudentSession Data
If All Levels = pass
***View theIntended-Lecture*Object**

IV. EVALUATION

To evaluate the performance of this intelligent e-learning system, 20 students were asked to evaluate the prototype version for the usefulness and efficiency of the system, and according to the experimental results, 17 of the students commended to use it. Students were satisfied with intelligent learning environments regarding the convenience and efficiency. The evaluation results were considered positively in respect to increasing the quality of e-learning in satisfying individual needs and ease of use, which allows the student to concentrate on learning goals all the time. To provide learner with more suitable personalized learning material, the pre-processing technique is applied using a multi-attribute evaluation method. It is based on the individual preferences, intellectual level and learning style extracted from the learning path.

Personalized search engine system has been proposed which implicitly collect student's personal information, test questions, his answers, required lecture, and the recommended learning objects.

The proposed model enhances the personalized learning using techniques for identifying student intellectual knowledge levels and learning style.

Sometimes, several of MCQs cannot be answered immediately without some explanation because students asked about them during their real-time learning process. Content analysis showed that the learning results were significantly affected by the learner strategy but not by presentation modality. Another note is that the system lack of direct teacher-student communication and there is no possible interaction with other students or the teacher to explain questions. Moreover, the learning environment has to enforce the possibility collaborative working and learning through sharing ideas and resources amongst learners and improve the techniques of synchronous communication with others.

From our point of view, the best way to improve the learning process is to involve the lecturers during the development of an application. This will help to adapt the course materials to their special needs.

V. CONCLUSION

We can point out a number of essential advantages:

- Our system is a centralized learning system implemented on one server. It was easy to navigate and working with the system was fast enough. Grasping the main idea of programming in HTML is done in a relative short time. The system provides a better support in the process of learning. Students can learn at their own time and own location in independence in time and place.
- It focuses on being intelligent because of its capability to assess student's background knowledge through randomized and well selected questions. The student followed the learning path that is proposed by the system and used the system‘s guidance. Using adaptive auto-evaluated questions that are used in searching for, selecting, sequencing and retrieving the appropriate lecture for the student.
- Lectures content materials are organized hierarchically and the learning units contain different media types such as text, power point slides, and audio and video-based course contents. Lectures are short duration.
- Given lectures are adapted to the student needs, in addition to student knowledge in the subject. It provides customized course contents and study guidance to individual student. It enables the students to select their modular components to adapt their student-centric learning environments.
- Recording the student's interaction data with the system can provide more accurate data regarding the student's learning style and permit track student records and history.
- It dynamically adapts learning content to fit student real-time needs.

ACKNOWLEDGEMENT

The authors are grateful to the Applied Science University in Amman, Jordan for the partial financial support granted to cover the publication fee of this research article.

REFERENCES

[1] Riad A. M., El-Minir K. H., and El-Ghareeb A. H., Review of e-Learning Systems Convergence from Traditional Systems to Services based Adaptive and Intelligent Systems, Journal of Convergence Information Technology, Vol. 4, Number 2, June, 2009.

[2] Horton W., and Horton C., E-Learning Tools and Technologies, Wiley Publishing Inc., 2003.

[3] Dziuban C. D., Hartman J. L., Moska P. D., Blended Learning, Vol. 2004, Issue 7, Educase Connect, 2004

[4] Nacheva-Skopalik, L., and Green S., E-Assessment For Adaptable Personal Learning, Proceedings of the International Conference on Information Technologies (InfoTech-2011), PP. 363- , 372, 15-16 Sep., Bulgaria, 2011.

[5] A Conceptual Architecture for the Development of Interactive Educational Multimedia, chapter 5, Idea Group Inc., 2006. Available at: http://www.irma-international.org/viewtitle/31362/

[6] Bork A., Bagley C. A., Zhang X., Technology and Learning: A proposal for Adaptive Learning Tutorial, Michael Allen's 2008 e-Learning Annual, J-B Pfeiffer Annual Loose leaf, Vol. 1, 2008

[7] Marcos, L., Pagés, C., and Martínez J., Competency-based Learning Object Sequencing using Particle Swarms, Tools in Artificial Intelligence. Available at: http://cdn.intechopen.com/pdfs/5281/InTech-Competency_based_learning_object_sequencing_using_particle_swarms.pdf

[8] Ma, Z., Web-Based Intelligent E-Learning Systems: Technologies and Applications**,** Automatic Learning Object Selection and Sequencing in Web-Based Intelligent Learning Systems, chapter 3, Idea Group Inc., 2006**.** Available at: http://www.irma-international.org/viewtitle/31360/

[9] Green, S., Pearson, E., Gkatzidou, S. (2009). Personalization, profiling and adaptation for inclusive e-learning support, International conference Infotech'09, St. Konstantain and Elena, 16-20 Sep., 2009.

[10] Tzouveli, P., Mylonas P., and Kollias S., An intelligent e-learning system based on learner profiling and learning resources adaptation, computer and Edu., 2007. Available at: http://www.image.ece.ntua.gr/papers/494.pdf

[11] Kinshuk, Taiyu Lin, Paul McNab, Adaptive Support for Inductive Reasoning Ability, Information Science Publishing, USA, 2006.

[12] Roy A., and Roy J., Adaptive E-learning System: A Review, International Journal of Computer Trends and Technology- March to April Issue 2011. Available at: http://www.ijcttjournal.org/volume-1/issue-1/ijcttjournal-v1i1p21.pdf

[13] Su, J. M., Tseng S. S., Lin, H. Y., and Chen C.,H., A personalized learning content adaptation mechanism to meet diverse user needs in mobile learning environments. Available at: http://www.springerlink.com/content/q6753774202026p7/

[14] Cristea P. D., and Tuduce R., Test Authoring For Intelligent E-Learning Environments, Inernational t Conference Web-Based Education, PP. 402-407, Feb. 16-18, Austria, 2004. Available at: http://ben.upc.es/butlleti/innsbruck/416-805.pdf

[15] Kose U., and Deperlioglu O., Intelligent Learning Environments Within Blended Learning For Ensuring Effective C Programming Course, International Journal of Artificial Intelligence & Applications (IJAIA), Vol.3, No.1, PP. 105-124, January 2012. Available at: http://airccse.org/journal/ijaia/papers/3112ijaia09.pdf

[16] Miettinen, M, Kurhila, J., and On the Prospects of Intelligent Collaborative E-learning Systems. Available at: http://cosco.hiit.fi/edutech/publications/aied2005.pdf

[17] Nedeva, V., and Nedev,D., Evolution in the E-Learning Systems with Intelligent Technologie, International Scientific Conference Computer Science'2008s, PP. 1028-1034. Available at: http://csconf.org/Volume3/page1028.pdf

[18] Zhao, Z., Feng, S., Zeng., Q., Fan, J., and Zhang, X., Personalized Knowledge Acquisition through Interactive Data Analysis in E-learning System, Journal of Computers, Vol. 5, No. 5, PP. 709-716, May 2010. Available at: http://ojs.academypublisher.com/index.php/jcp/article/view/749

[19] Karampiperis, P., Automatic Learning Object Selection and Sequencing in Web-Based Intelligent Learning Systems, Chapter 3 in eb-Based Intelligent E-Learning Systems: Technologies and Applications edited by Zongmin Ma , Idea Group Inc., 2006. Available at: http://www.irma-international.org/viewtitle/31360/

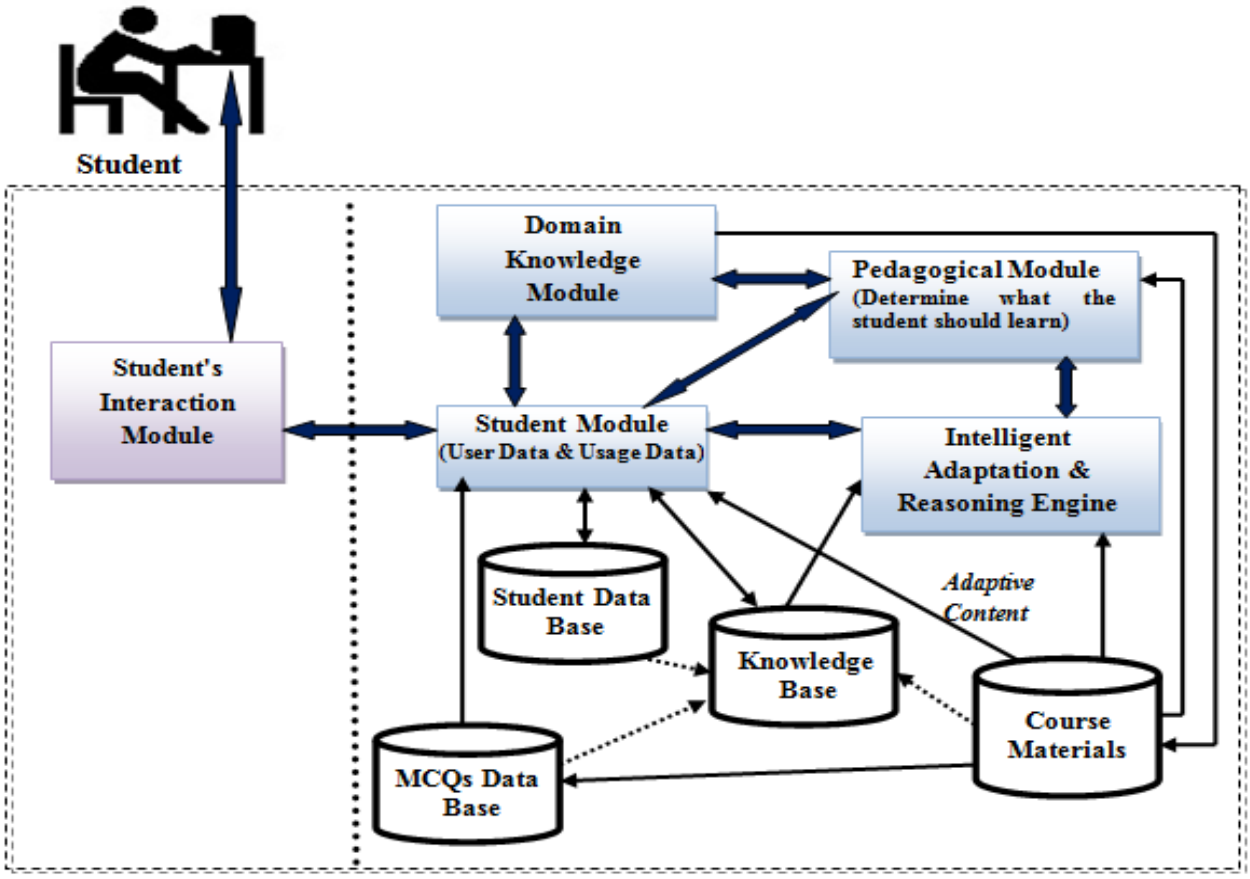

Fig. 2.The proposed framework of the intelligent student-centered e-learning system.

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

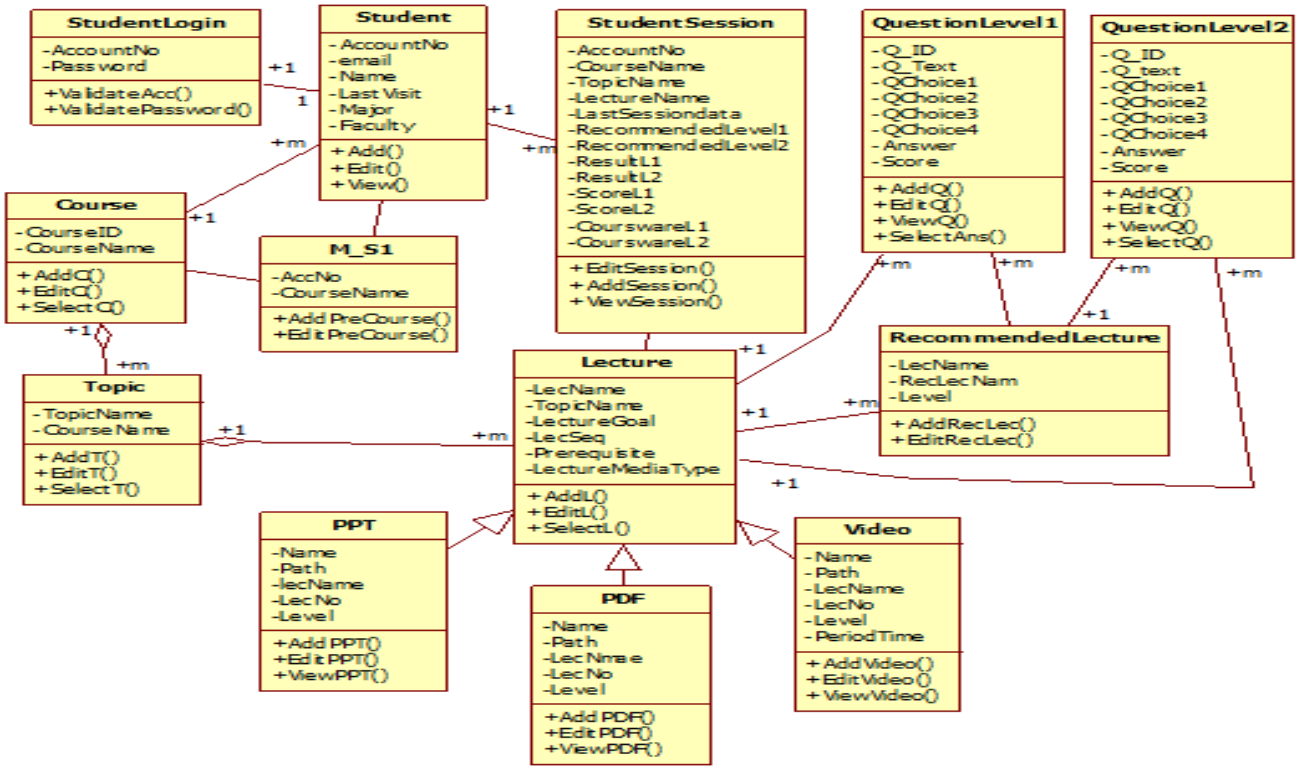

Fig. 3. The Class Diagram for Intelligent Student-Centered System

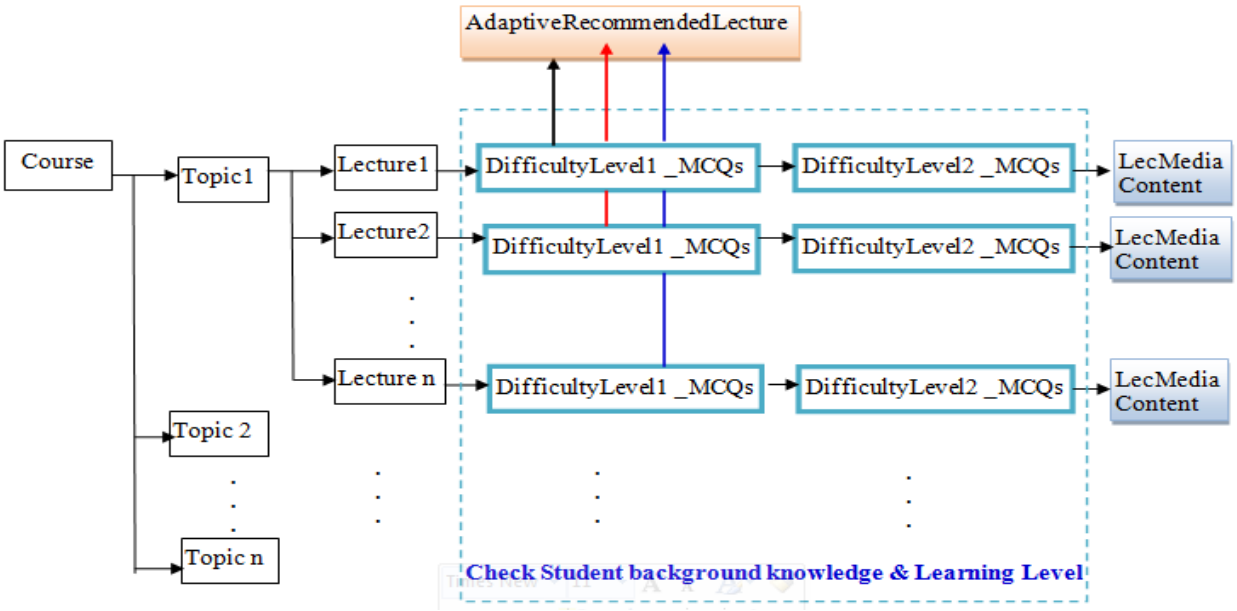

Fig. 4. Inherited Object-Oriented Structure of the Course Materials

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)