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A Model of Adaptive E-Learning in an ODL Environment

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ABSTRACT

In recent years, technology enabled learning also called e-learning is penetrating in the educational sector and its use is increasing especially in ODL (Open and Distance Learning). But a majority of the e-learning systems merely focuses on instruction delivery with little focus on learning activities and thus creating opportunities to develop e-learning more interactive and engaging by adding adaptive features. However, it is also a challenging task to develop and implement an adaptive e-learning model for an ODL environment. There are various issues like non-availability of the specialized contents, the learning sequence story board and the preferences of learners under the available infrastructure. This paper proposes a model of adaptive e-learning for an ODL environment. The proposed model has three important components: content model, learner model and adaptive model. The content model defines and stores the organization of chapters and topics in a logical sequence. The learner model stores information about survey and quizzes data and keep the track of the learning performance. The survey is designed to investigate the personal profiles and the preference of students about their favorite content types. The adaptive model manages content presentation and its navigation derived by the learning algorithm. The learning algorithm takes information from the learner model, analyzes it and adjusts the display of the contents by retrieving it from the content model. The implementation was conducted on two courses of computer science and in each course the experimental and control groups were formed to investigate the change in their learning level. The results show that the proposed adaptive e-learning model has improved the knowledge level of the students. The percentage of highest grade holders has increased and the failure rate has dropped in both courses. The feedback of the students enrolled in adaptive e-learning course is also conducted. The results of the survey highlight the positive opinion about this new paradigm of technology based learning.

Key Words: Open and Distance Learning, E-Learning, Adaptive, Content Model.

1. INTRODUCTION

ODL is a non-traditional system of education which is independent of distance and time. It gives greater autonomy to the learners by providing anywhere anytime learning and training opportunities [1]. Due to flexible mode, the ODL mode is growing rapidly and traditional institutes are also converting their programs into ODL environment. When computer technology was introduced in education, it got

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more attention in distance learning due to its potential of remote access & services and thus a new paradigm of e-learning or online learning was introduced. E-learning is the electronic means of education through the use of technology [2]. It uses computers and mobile phones to manage virtual educational activities in an ODL environment [3]. These activities require synchronous & asynchronous interactions between the teachers and the students [4]. It also involves the provision of the digital contents that can fulfill the dynamic needs of the distant learners [5]. However, the development of appropriate digital contents in an ODL setting is a real challenge because the students of present modern era don't have sufficient free time to browse lengthy contents. They require right content at the right time with minimum duration and maximum information.

Adaptivity in e-learning can meet the compact and dynamic needs of the students. It can create appropriate learning scenarios by considering their diverse needs and requirements [6]. Brusilovsky [7] has termed adaptivity important because learners differ in their qualities, preferences and styles of learning. They need their favorite type of contents without considering what others need. The adaptation based on specialized content and its delivery over local ICT (Institute of Communication Technology) infrastructure is a real challenge. It is complex due to diverse characteristics of students, time consuming due to the tailoring of separate learning paths for individual learners and expensive due to the high cost of domain experts [8]. This paper addresses these challenges by proposing a model of adaptive e-learning. It is based on the international standards of e-learning customized in a localized environment. The paper is organized in six sections: section 2 presents the literature review, section 3 highlights the survey results on the profiles and the preferences of ODL learners, section 4 presents the proposed model of adaptive e-learning and discusses its main components, section 5 presents the experimental results and the section 6 concludes the paper.

2. LITERATURE REVIEW

Adaptability in e-learning is the changing ability of system that can fulfill individual academic needs. The idea emerged when researcher began to work on personalized learning systems [9]. These systems can transform teaching activity into learning phenomena by analyzing profiles of students [10]. There are four theoretical approaches that form the basis of adaptability in e-learning. They are "macro adaptive instruction, aptitude treatment interaction, micro adaptive approach and constructivist collaborative" [11]. The macro adaptive approach focuses on the mapping of the learning objectives with depth and breadth of contents. It aims at achieving the learning outcomes by developing knowledge and skills among the students [12]. The addition of the student's characteristics is proposed by Aptitude Treatment Interaction. The theory suggests that there is diversity in the students' beliefs; therefore they need a suitable instruction format which matches with their personality [13]. The micro adaptive approach works on micro level by analyzing ongoing learning tasks and interaction activities. The process is used to diagnose weak areas and generate academic prescription to inhale these weak areas [14]. The indicators of assessment tests, response time and emotional states are used to develop the student knowledge-base. The constructive collaborative approach focuses on the performance investigation through perception. The students construct their own knowledge by focusing on their mistakes and use experience to gradually improve their knowledge. It gives autonomy to the students in learning at their own pace [15].

The theoretical foundations lead the dimension of adaptive learning towards AIWBES (Adaptive and

Intelligent Web-Based Educational Systems) [16]. AIWBES are further divided into ITS (Intelligent Tutoring Systems) and AH (Adaptive Hypermedia). ITS are very specialized learning systems that are restricted to narrow domains [17]. Due to limited scope, separate ITS is required for different subjects which is not feasible due to the high development cost and the diverse training needs [18]. On the other hand AH provides an alternate solution against the issues of ITS [19]. AH are more generalized and less expensive that work along intersection of hypertext (hypermedia) and student modeling [20]. There are three core components of AH: domain model, student model and pedagogical model [21]. The domain model identifies subject, topics, different types of learning objects and related concepts. The student model captures the general information and the interaction details of the students during online activities. The information stored both in the student and the domain models is used by pedagogical model. It decides when to present next topic to the individual or a group of students on the basis of their performance. It may also help to align learning objects as per specific needs of the learners.

Numerous research studies have been presented in the literature on adaptive e-learning. The focus of studies is on the aspect, what can be adapted and how? The literature review provides the answer by classifying two broad areas of adaptive presentation and adaptive navigation [22]. The adaptive presentation focuses on the presentation of contents in the form of text and multimedia. The presentation and the retrieval of the required learning object is determined on the basis of relevance with the user needs, preference and interest [23]. The navigation is controlled by direct control & guidance, link sorting & hiding, link annotation, map adaptation and link generation. These are the techniques of hiding and seeking content links according to their relevance for the users [22]. These techniques are built upon student model that store and analyze the diverse characteristics and profiles of students [24].

A number of research models have been proposed in the field of adaptive e-learning employed for educational domains. These studies differ in the content authoring mechanism, the user modeling and the instructional strategies. The content authoring tools are used to tailor e-contents for the e-learners. They provide a mechanism of arranging learning contents to suit the specific needs of the learners. Some important authoring tools are, AMAS, GRAPPLE, MOT, and ACCT. The AMAS authoring tool facilitates users having basic ICT competence to create adaptive e-learning components using a graphical user interface [25]. It does not require any coding or rules to be defined. GRAPPLE provides an adaptive e-learning environment that guides learners through their life-long learning experience and makes adaptions based on their knowledge, preferences and competencies. The adaptive functionalities are coupled with the LMS (Learning Management Systems) to incorporate the user modeling approaches [26]. MOT is another authoring tool that tailors adaptive hypermedia resources. It is a flexible tool where the contents are separated from the learning goals however the usability of MOT is low [27]. AHA is a generalized adaptive hypermedia tool, which provides course modeling approaches. The course is organized as web pages with hypertext and hypermedia links [28]. ACCT (American College of Commerce and Technology) is another authoring tool which was capable to author high-level descriptive concepts by defining pedagogical strategies and related tasks in a systematic manner [29]. All these content authoring tools work to define content scenarios but they are limited to research and development and no tool is open and flexible enough to meet the diverse needs of learning in different domains. Some of the issues with existing authoring tools are design complexity [30] and absence of pedagogical considerations [31].

The user modeling is another important parameter in the construction of adaptive e-learning. The selection of attributes is the basic building block of the learner model. According to Yang et. al. [32] a student model should consider both domain dependent and domain independent characteristics. There are a number of research studies which have considered the different attributes of students to construct user models. Klasnja-Milicevic et. al. [33] proposed an intelligent system for e-learning personalization based on learning styles of students. The proposed system named as Potus also analyzed the habits and preferences of learners by using the log files. Lekkas [34] used personality, emotions, cognitive styles and problem solving styles to determine the learning experience. Van et. al. [35] used demographics data and motivation of learners for the development of adaptive contents. The study revealed that higher intrinsic motivation, prior knowledge and study level are important while using adaptive e-learning. Hsu et, al. [36] used preferences and knowledge level to propose a mobile learning based recommendation system. These research studies have shown that the personal and the demographics characteristics of the learners have strong impact on the design and the development of adaptive e-learning systems. Additionally their learning and cognitive styles have also been proved significant for the development of specialized e-learning models [37].

The adaptation model and instructional strategies are yet another important criterion for the design and the development of adaptive e-learning. Adaptation techniques use information from the user model, apply algorithm and arrange learning contents to align the concepts according to the individual user's needs. There are research studies that have focused on adaptation techniques. Esichaikul et. al. [38] proposed a research model of adaptive e-learning comprising of the domain model, the student model and the adaptive model. The adaptive model use Dempster-Shafer theory to analyze data in the student model and locate learning objects from the domain model according to the student's knowledge level. Kumaran [39] proposed a recommendation scheme for the adaptive e-learning using a frame network. The model uses the learner's behavior to analyze learning needs and proposes appropriate learning contents. The semantic net was used to navigate and search through learning objects in support of the personalized assistance. Nasim [40] presents a model of MALOR (Multi-Adaptive Learning Object Repository) which focused on unified web-based educational systems. The adaptability model was divided into two sub models: the adaptability selection and the adaptability merge. The adaptability merge model intersected the results of each adaptable approach for the selection of a suitable learning object for the learners on the basis of their learning styles. Dolenc et. al. [41] proposed an individualized ITS based on the cognitive characteristics of the learners. The adaptation technique automatically adjusted the difficulty level of the contents based on metadata analysis of the learners' interaction. Kanimozhi et. al. [42] presented a model of adaptive reusable objects which were compiled from the existing bulk material available on the WWW (World Wide Web). That adaptation model used cognitive behavior attributes to present the appropriate leaning objects to the learners.

All the adaptive e-learning systems and models work to enhance the learning level of students but they differ in the content hierarchy, learner model and adaptation techniques [43]. They also differ in complexity, teaching strategy and the level of implementation. Most of the adaptive e-learning models are being developed for specialized domains and for specific group of learners. The adoption of such adaptable e-learning models is not easy due to a variety of issues such as the absence of instructional design methodologies for e-learning [44], load shedding [45], fast Internet connectivity [46], understanding of contents written in high level English [47] and non-availability of localized contents [48].

Therefore, there is a dire need and growing demand to develop a generalized adaptive e-learning model that not only complies with the international e-learning standards but is also suitable to fulfill the needs of the local learners. Before presenting the conceptual framework a survey was conducted to determine the profiles and the preferences of learners for an adaptive model construction.

3. PROFILES AND PREFERENCES OF ODL STUDENTS

The adaptive e-learning in an ODL environment can be made more interactive if perspective and inclinations of ODL students are considered. The conceptual model may be developed in the light of the students preferences. In this connection, a questionnaire was developed to investigate their intentions about using adaptive e-learning in an ODL environment. The survey was conducted from the students of CS (Computer Science), AIOU (Allma Iqbal Open University), Islamabad, Pakistan. This domain was selected because CS students already have basic ICT skills and they can provide effective feedback about advance e-learning systems.The survey results were analyzed as described in the next sub section.

3.1 Demographics

The demographics results are shown in **Table 1**. The results reveal that ratio is dominated by males with 81.6% but female has considerable proportion with 18.3%. The majority of the students belong to 21-30 age with 64.3% but there are notable representations from other age groups as well. The location of study is also occupied by urban area with 73.4% but there are a sizeable number of students from semi-urban and rural areas of the country.

3.2 Adaptive E-Learning Preferences

The preferences of the students were evaluated about the adaptive e-learning. The mean value and standard deviation results show the high preferences of the students as shown in Table 2. The respondents are of the view that e-content available on PC or mobile will improve their learning. They have preferred different formats of learning contents that can match with their preferences and styles of learning. The students desire to have simple navigational controls during the content browsing in a

TABLE 1. STUDENTS' DEMOGRAPHIC PROFILE

Variable	Frequency	Frequency (%)
Gender		
Male	142	81.6
Female	32	18.3
Total	174	100
Age Group		
Less than 21	39	22.4
21-30	112	64.3
31-40	18	10.3
More than 40	5	2.8
Total	174	100
Location		
Urban	113	73.4
Semi-urban	37	9.9
Rural	24	16.7
Total	174	100

logical sequence that matches with their learning. The interface should be controllable and friendly so that they can learn at their own pace. The e-assessment can be integrated with the learning contents so that they can analyze and correct their mistakes. The majority of the students are of the view that adaptive e-learning can enhance ODL system and university should adopt this model to improve teaching and learning. It can help to improve the quality of education.

4. PROPOSED ADAPTIVE E-LEARNING MODEL

Following the literature survey and the preferences of the students the conceptual model of adaptive e-learning is proposed as shown in Fig. 1. This model has four important components: the content model, the learner model, the adaptive model and the communication interface.

4.1 Content Model

The content model is based on learning objects which are the instances of digital entities in the form of computer based instructions. These instructions are comprised of course details and media objects i.e. text based lessons, animations and hands on exercises as shown in **Fig. 2**. The lessons are self-learning web based tutorials developed in HTML (Hyper Text Markup Language), animations are moving artifice created in flash multimedia and exercises are hands on exercises defined through activity webpages. The depth of the chapter is defined at different levels of learning topics (level-1, leve-2 and level-3) in order to meet needs of novice, intermediate and advance learners respectively. The SCORM (Shareable Content Object Reference Model) is adopted to define the media objects for each level of topic. These media objects are made up of Assets and SCOs (Sharable Content Objects) that define the organization and aggregation of learning topics in the content model [49]. The Assets are the lowest level of learning contents that comprises of HTML documents, flash files, audio and video clips. The SCO is a collection of one or more Assets that may be used in a variety of contexts to fulfil learning objectives. Assets and SCO are packaged in three formats as shown in Fig. 2. The learners interact with SCO and Assets through a user interface.The lessons, animations and exercises represent a coherent learning object, which is mapped with three levels of learning concepts as defined in the topic hierarchy. All the chapters correspond to a course which is at the top level and defines a larger concept of knowledge that fulfills learning objectives of the courses.

TABLE 2. ADAPTIVE E-LEARNING PREFERENCES

Adaptive e-Learning Preferences	N=174	
	Mean	SD
E-content available on my PC or mobile will improve my learning	4.1	0.94
I need different types of e-content on multiple topics varying from text to animations.	3.8	0.95
The content developed should be easy to navigate	4.1	0.90
The learning sequence should match my understandings	3.8	1.03
The interface should be adaptable according to my preference	3.5	1.2
The assessment should be linked with each content	3.4	1.1
I would like to see and analyze my misconceptions	3. 7	1.1
Adaptive e-learning can enhance ODL system	3.9	0.98
Adaptive e-learning should be introduced in the university	4.1	1.02
The adaptive e-learning model can improve the quality of educational programs	4.2	1.01

The learning concepts are evaluated by assessment objects which composed of a short quiz that is associated with each learning level. On the basis of the quiz results the students are assigned a rank from novice, intermediate and advance stereotypes.

4.2 Learner Model

The learner model stores information about learners. It stores two types of information: domain independent and domain dependent data [50]. The domain independent

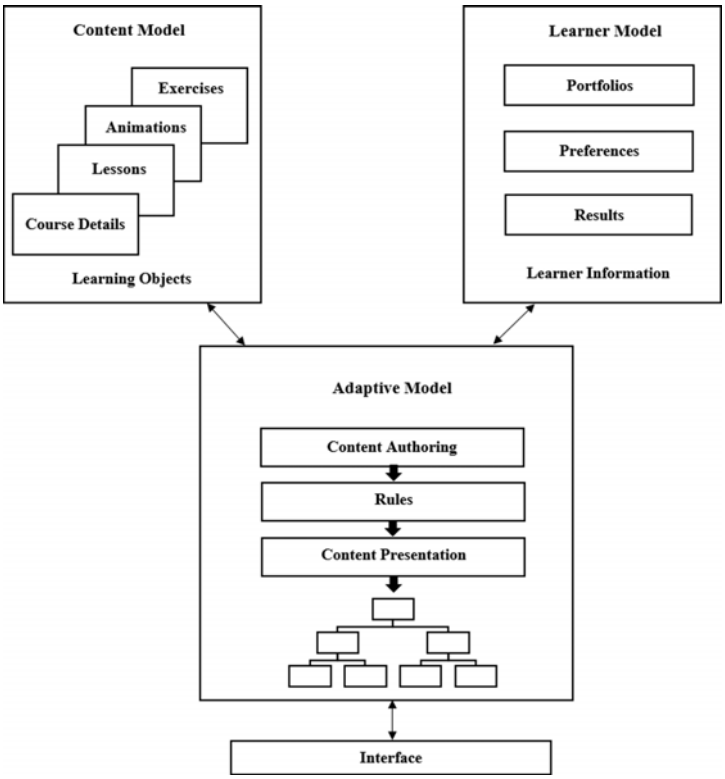

FIG. 1. PROPOSED MODEL OF ADAPTIVE E-LEARNING

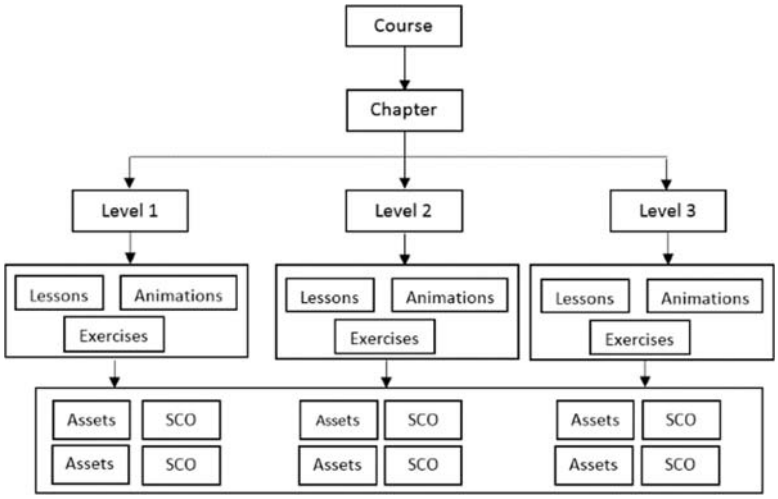

FIG. 2. CONTENT MODEL

data is composed of the personal information, demographic information and preferences. The domain dependent data is specific to a particular domain and maintains assessment results. Students are divided into three classes i.e. novice, intermediate and expert learners. The student knowledge-base is maintained by assigning one of the ranks from these stereotypes. The transformation of content model to the learner model is shown in Fig. 3. The chapter contents are available up to three levels of difficulty i.e. level-1 for the novice, level-2 for the intermediate and level-3 for the advance learners. The adaptive model (defined in next section) controls the content presentation and navigation based on performance of students.

The assessment results determine the learning level of learners as shown in Table 3. The automated quizzes are associated with each difficulty level of the topics as defined by the teacher. The learners play the adaptive contents and appear in the automated quiz during a time period set by the teacher. The system evaluates the result and store the performance in learner model. The learners who get less than 50% marks are placed in novice group with learning level-1. The intermediate group resides above 50% that goes up to 70% and fall into category 2 of the learning level. The last group is composed of the expert learners having a more than 70% mark that touches to level-3. The learning levels can be changed by the instructor according to nature of the course and overall historical class performances. The learning algorithm (defined in next section) uses this stereotype information to control the content presentation. The information of student model is stored at backend in MySQL database of the adaptive e-learning system.

4.3 Adaptive Model

The adaptation criterion makes use of the content and the learner models to implement the adaptive model. It is composed of content authoring and rules for content presentation. The important driver is the content presentation algorithm, which is shown in Fig. 4. The learner interface loads the preferred content from the content model. When the leaner logs into the systems, the algorithm gets the chapter number, content level, preference and learning level stored in the learner model based on his previous achievements (step 1-4 of the algorithm). The chapter number, the content level and the learning level are initialized to 1 in the learner model when he/she registers for a course. Every topic starts with the initial level content of a unit/chapter that is provided in three formats as discussed in section 4.1. The preferred contents of each topic are displayed and interaction details are stored in the learner model (step 5). Each topic is followed by an evaluation quiz to evaluate learning level of students. The quiz results are used to determine the achieved learning level of learners (novice,

TABLE 3. LEARNING LEVEL AND STUDENTS' STEREOTYPE

Stereotype	Interval	Learning Level
Novice	Marks $\leq$ 50	1
Intermediate	50 < Marks $\leq$ 70	2
Expert	70 < Marks $\leq$ 100	3

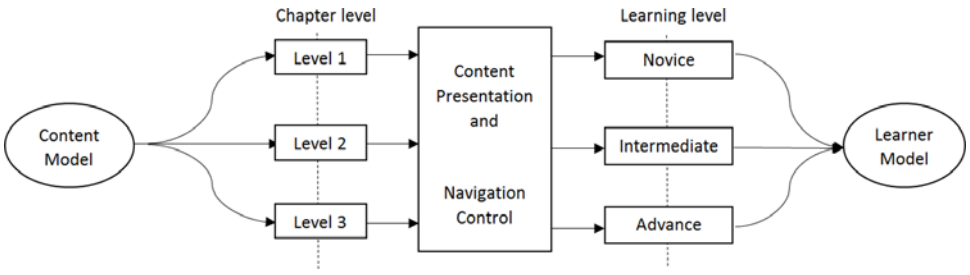

FIG. 3. STUDENTS' STEREOTYPE

intermediate or expert). If the learners achieved knowledge level is novice or intermediate, he/she has to browse the contents and take the quiz again until attainment of the advance level of learning (step 6). After completion of the three levels of knowledge for a chapter, the learner can move to next chapter (step 7). Note that the adaptation rules specified in the algorithm control the display of pages from the content model using assessment data from the student model. The navigation control uses the link hiding and link generation technique to control the learning activities. The learner model is updated with the progression of student at each level (step 8).

The threshold values selected are based on university grading scheme. The 50 or less than 50 marks indicate poor performance of leaner. Hence these students are regarded as novice learners. Similarly the students who score 51-70% of marks indicate that the students have satisfactory or average level of knowledge and skill in the course and therefore we treat them as intermediate learners. The advance learners are those who secure 71-100% marks.

4.4 Interface

The interface provides a set of command menus to interact with the adaptive e-learning system. The teacher uses this menu to author the contents and associate assessment objects. The students use this menu to participate in adaptive e-learning tasks as defined by the teacher. The interface makes it easy both to participate in adaptive e-learning tasks and to navigate steps. The student's preferences are used to minimize the steps while going through the contents in a logical manner. The architecture of a prototype is discussed in the next section.

4.5 System Implementation

The three tier Client/Server architecture as shown in Fig. 5 was used to implement the proposed research model. The client side deals with the user interface while server sides manage applications and the database. The applications are composed of content authoring, content presentation, survey and assessment modules.The authoring application enables teachers to

```
Step-1. chapter_no=getChapterNo()
Step-2. content_level=getContentLevel()
Step-3. learning_level=getKnowledgeLevel()
Step-4. preference=getPreference()
Step-5. while (chapter_no<=TotalChapter AND !done())
    {
display_contents(chapter_no, content_level,learninge_level,preference)
quiz=generate_quiz(chapter_no, content_level, learning_level)
display_quiz(quiz)
get_student_answer(answer_list);
marks=grade(answer_list);
Step-6.  if (marks <=50) learning_level=1
else if (marks>50 and marks<=70) learning_level=2
  else learning_level=3
Step-7.  if (learning_level=1 or learning_level=2) continue
else if (content_level=3)  {
chapter_no=chapter_no+1
learning_level=1
content_level=1;
}
else content_level=content_level+1;
}
Step-8. update_learner_model();
```

FIG. 4. ALGORITHM FOR ADAPTIVE CONTENT PRESENTATION

compile and create interactive media objects and upload them on the main website. The content presentation is managed by the learning algorithm described in Fig. 4. The survey module is designed to take data from the students. The assessment modules implement the quiz strategy discussed in section 4.2.

A relational database model is used to manage the content, the assessment and the students' information. The students can login and interact with the system by using a browser. The student interface allows them to download the contents of their preferred choice and participate in online quizzes as per program pedagogy. They can progress through the course as per adaptation rules. Teachers can login to the system and can upload the contents and assessment object. They can control the sequence of learning objects as per learning algorithm. The prototype is implemented by using PHP (Hypertext Preprocessor) server based technology which uses MySQL database at the backend. The selected screen shot is shown in Fig. 6. It comprises of links to adaptive contents: lessons, animations and exercises.

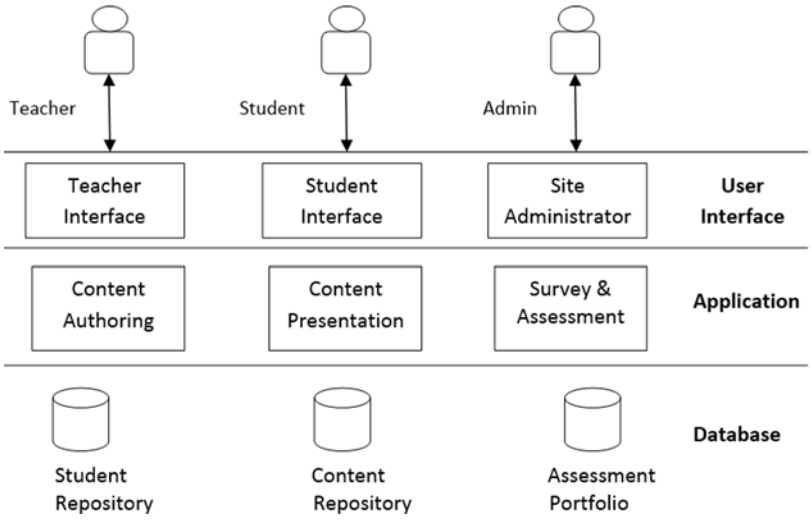

FIG. 5. THREE TIER CLIENT/SERVER ARCHITECTURE OF ADAPTIVE E-LEARNING MODEL

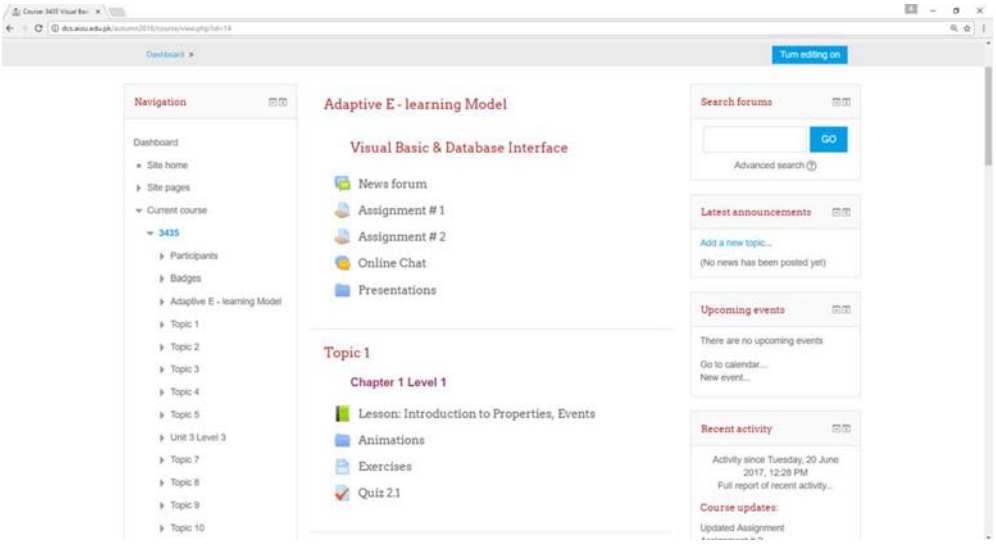

FIG. 6. SCREEN SHOT OF ADAPTIVE E-LEARNING COURSE

5. EXPERIMENTAL RESULTS

An experiment was carried out to observe the effects of adaptive e-learning on the examination results of the students. It was implemented on two courses of computer science: software engineering and visual basic. These courses were selected after consultation with education and technology expert who emphasized to select one course from theory and one from the practical nature. This gives a fair and valid comparison of their performances in different courses. One hundred and ten students were randomly selected in the experimental setup. All were the students of PGD (Post-Graduate Diploma) CS program offered at AIOU, Pakistan. They were randomly divided into two groups- experimental and control and each group was comprised of 55 students. The experiment was completed in two phases. During the first phase the students were registered in the courses. They filled the registration form comprising of personal and demographic information. Additionally, the students of experimental group were asked to complete a preference questionnaire regarding the adaptive e-learning features. During the second phase the students of both groups participated in the semester activities as per university schedule. The students of experimental group were given the adaptive contents and they were allowed to play and replay the contents as per learning algorithm discussed in section 4.3. On the other hand the students of the control group were given the traditional contents and there was no mechanism to control their learning pace while browsing the contents. The same examination paper of the relevant subject was given to both groups and their performance was measured. The experimental group browsed their preferred contents and appeared in self-learning quizzes. The learning level of students went through novice, intermediate and expert phases. The learning process was controlled by adaptation rules defined in the algorithm. The other activities were completed as per semester schedule. The time schedules were set by the teacher within the semester duration. The control group browsed the traditional contents as routine semester activities. At the end of the semester the result of students was prepared as per university criteria. The results of experimental and control groups were compared for both courses. The comparison of grades for software engineering course is shown in Fig. 7 and the comparison for visual basic course is shown in Fig. 8.

In software engineering course, the 12.7% of the students of experimental group (adaptive batch) got A+ grade as compared to 7.3% of the control group (non-adaptive batch), which shows improvement in highest grade. The other grade proportions for experimental group were 10.9% A, 16.4% B and 25.5% C Grade which were comparable with the control group grade holders i.e. 12.7% A, 18.2% B and 12.7% C Grade. Another important result

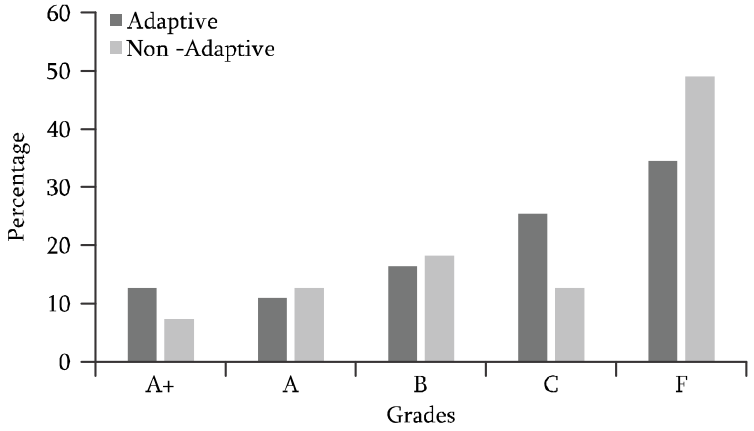

FIG. 7. RESULT COMPARISON FOR SOFTWARE ENGINEERING COURSE

found was decrease in failure rate which dropped to 34.5% of the experimental group as compared to 49.9% of the control group. Similarly, in visual basic course the highest grade holders for experimental group were 27.6% as compared to 15.8% of the control group. The A grade holders were also high 24.1% as compared to 18.4%. The B grade holders were almost same i.e. 27.6 and 26.3% in the experimental and the control group respectively. The failure rate decreased significantly to 6.9% as compared to 23.7%. The overall class progress of adaptive batch has improved as shown by the results.

The usefulness of adaptive e-learning model was also conducted through a feedback survey questionnaire. The objective of this survey was to get opinion of students about different aspects of adaptive e-learning model. The results shown in Table 4 reveal a positive feedback as mean value calculated was higher, from 3.2-3.8. The learning model has fulfilled students' expectations as the adaptive content helped to improve their learning. These contents were easily downloadable on their systems with heterogeneous Internet connections. The navigation controls were easy to follow and interface was friendly. The contents presented matched with the curricula and the learning styles of students. The enabling and disabling of link gave them confidence to progress at their own pace. The quiz module was appropriate to assess their learning level. They valued that pedagogy and expression was better than other courses and helped them in the preparation of examination.

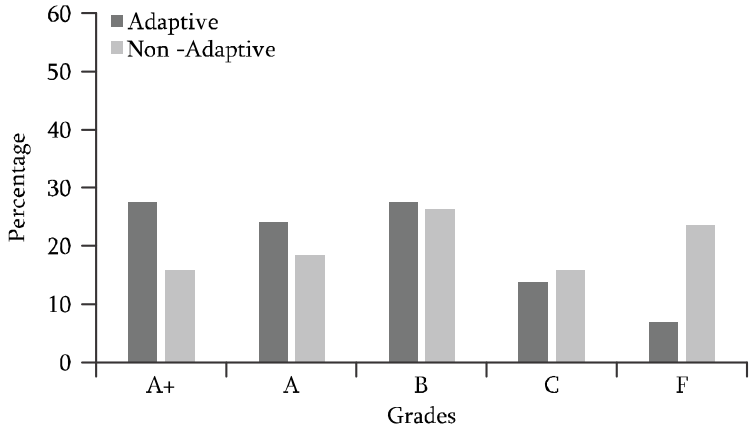

FIG. 8. RESULT COMPARISON FOR VISUAL BASIC COURSE

TABLE 4. FEEDBACK RESULTS

Feedback	N=55	
	Mean	Standard Deviation
The adaptive e-leaning model fulfilled your expectations	3.4	0.9
Have the contents presented helped to improve your learning?	3.2	0.7
The contents were downloadable with your existing Internet connection	3.3	0.7
Was navigation controls easy to use?	3.6	1.0
Was the graphical user interface of website easy to operate?	3.8	1.0
How do you rate matching of the contents presented with your course curricula and your style of learning?	3.7	0.7
Did enabling and disabling of link (until attainment of required learning level) was suitable?	3.7	0.9
How do you rate the quiz module	3.5	0.9
Do you think that other courses of semesters should be offered in adaptive e-learning mode	3.6	0.9
Did you think that expression in adaptive e-learning course was better than other courses in your program?	3.4	0.7

6. CONCLUSIONS

Adaptive e-learning is the future of next generation online learning. The existing adaptive models are designed for specialized domains; therefore, a model or system developed in one environment may not be successful in others due to a variety of challenges like the lack of specialized contents, the learning sequence story board and the preferences of learners. There was a need to design a generalized model that can be adjusted in different domains and can maintain the learning pace of students with diverse knowledge levels in a systematic way. Considering these motivations, this paper has presented the theoretical foundations and the current development in adaptive e-learning. On the basis of literature a model of adaptive e-learning has been proposed according to the international standards of e-learning. The profiles and preferences of the students have also been considered for conceptualizing the model components. The proposed model has three components, content model, learner model, and adaptive model. The content model deals with the organization of contents keeping in view the depth and breadth of topics. The learner model stores information about portfolios and assessment results. It also stores the survey data which was conducted to investigate the preferences and personal profiles of students. The adaptive model presents the contents as per learning algorithm, which controls the content presentation and navigation control based on the performance of the students. The prototype was implemented by using open source technologies. The student interface was specially designed to control the learning sequence as per adaptive algorithm. The teacher interface was developed to upload the contents and define the rules for sequencing and navigation control.

The model was implemented on two computer science courses. The students were enrolled in the courses as per criteria and they participated in adaptive e-learning activities with other activities of the semester. The examination marks of experimental group were compared with the examination marks of control group. The results show that performance of experimental group that used adaptive e-learning is better than that of control group. There was significant increase in A+ grade holders and decrease in failures due to the specialized assistance provided by the adaptive e-learning. The feedback survey conducted from the students has also proved the confidence of students on adaptive e-learning methodology.

The research may be used as a reference model to improve the quality of ODL programs and courses. It provides an exciting dimension for future research on adaptive e-learning for the distant learning environments. The future research area deals with the development of the learning object repository of adaptive contents for different courses and programs. The development of semantic search and retrieval of the learning objects is also part of the future work. The intelligent assessment objects will be linked with semantic search to incorporate the personalized assistance. The examination policies will also be updated to accommodate the adaptive e-learning model.

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