# Adaptive E-Learning Based on Technology of Learning Navigation

**KaziFakirMohammed, VinitNimkar, SushoptiGawde**

***Abstract*—E-learning as we know it has been around for ten years or so. During that time, it has emerged from being a radical idea---the effectiveness of which was yet to be proven---to something that is widely regarded as mainstream. It's the core to numerous business plans and a service offered by most colleges and universities. When we think of learning content today, we probably think of a learning object. Originating in the world of computer-based delivery (CBT) systems, learning objects were depicted as being like lego blocks or atoms, little bits of content that could be put together or organized. Standards bodies have refined the concept of learning objects into a rigorous form and have provided specifications on how to sequence and organize these bits of content into courses and package them for delivery as though they were books or training manuals.**

**E-learning can occur in or out of the classroom. It can be self-paced, asynchronous learning or may be instructor-led, synchronous learning. E-learning is suited to distance learning and flexible learning, but it can also be used in conjunction with face-to-face teaching, in which case the term blended learning is commonly used.**

**Acknowledging the important relation between individual differences and education has very long history. However, simply acknowledging versus systematically testing this relation are two quite different things. Together with Lee Cronbach, Dick Snow formalized this interaction, consequently revolutionizing the thinking and researching of human abilities in the 1970s. Snow's primary research agenda focused on how individual differences in aptitudes played out in different educational settings. This receive worldwide attention in the classic book on aptitude–treatment interactions (ATIs; Cronbach& Snow, 1977). Snow was steadfast in his belief that the psychology of human differences is fundamental to education. He also acknowledged that designers of policy and practice often ignore the lessons of differential psychology by trying to impose a "one-size-fits-all" solution even though individuals are different. His work sought to change that fact—to promote educational improvement for all. This quest, across the years, has been joined by scores of supporters who have been motivated by him, either directly—as students and colleagues—or indirectly— through his writings. The first author of this article was fortunate to have had both direct and indirect Snow influences for almost 2 decades. And his influence continues, currently manifest in a research an**

**development stream called adaptive e-learning. As e-learning matures as an industry and a research stream, the focus is shifting from developing infrastructures and deliverin information online to improving learning and performance. The challenge of improving learning and performance largely depends on correctly identifying characteristics of a particular learners.**

***Index Terms*- Adaptability,Bayesian Network., e-Learning, Learning Navigation**

## I. INTRODUCTION

### *A. Introduction to E-Learning:*

E-learning (or eLearning) is the use of electronic media, educational technology and information and communication technologies (ICT) in education. E-learning includes numerous types of media that deliver text, audio, images, animation, and streaming video, and includes technology applications and processes such as audio or video tape, satellite TV, CD-ROM, and computer-based learning, as well as local intranet/extranet and web-based learning. Information and communication systems, whether free-standing or based on either local networks or the Internet in networked learning, underlie many e-learning processes.

E-learning can occur in or out of the classroom. It can be self-paced, asynchronous learning or may be instructor-led, synchronous learning. E-learning is suited to distance learning and flexible learning, but it can also be used in conjunction with face-to-face teaching, in which case the term blended learning is commonly used.

E-learning includes, and is broadly synonymous with multimedia learning, technology-enhanced learning (TEL), computer-based instruction (CBI), computer managed instruction,[2] computer-based training (CBT), computer-assisted instruction or computer-aided instruction (CAI), internet-based training (IBT), flexible learning, web-based training (WBT), online education, virtual education, virtual learning environments (VLE) (which are also called learning platforms), m-learning, and digital education. These alternative names individually emphasize a particular digitization approach, component or delivery method, but conflate to the broad domain of e-learning. For example, m-learning emphasizes mobility, but is otherwise indistinguishable in principle from e-learning.

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### *B. Benefits of E-Learning:*

- Class work can be scheduled around work and family
- Reduces travel time and travel costs for off-campus students
- Students may have the option to select learning materials that meets their level of knowledge and interest
- Students can study anywhere they have access to a computer and Internet connection
- Self-paced learning modules allow students to work at their own pace
- Flexibility to join discussions in the bulletin board threaded discussion areas at any hour, or visit with classmates and instructors remotely in chat rooms
- Instructors and students both report eLearning fosters more interaction among students and instructors than in large lecture courses
- eLearning can accommodate different learning styles and facilitate learning through a variety of activities
- Develops knowledge of the Internet and computers skills that will help learners throughout their lives and careers
- Successfully completing online or computer-based courses builds self-knowledge and self-confidence and encourages students to take responsibility for their learning
- Learners can test out of or skim over materials already mastered and concentrate efforts in mastering areas containing new information and/or skills

### *C. Adaptive Learning*

Adaptive learning is an educational method which uses computers as interactive teaching devices. Computers adapt the presentation of educational material according to students' learning needs, as indicated by their responses to questions and tasks. The technology encompasses aspects derived from various fields of study including computer science, education, and psychology.

Adaptive learning has been partially driven by a realization that tailored learning cannot be achieved on a large-scale using traditional, non-adaptive approaches. Adaptive learning systems endeavor to transform the learner from passive receptor of information to collaborator in the educational process.[1] Adaptive learning systems' primary application is in education, but another popular application is business training. They have been designed as both desktop computer applications and web applications.

Adaptive learning has also been known as adaptive educational hypermedia, computer-based learning, adaptive instruction, intelligent tutoring systems, and computer-based pedagogical agents.

## II. DESIGN OF RELATED ALGORITHM OF ADAPTIVE LEARNING

The adaptive algorithm in this paper is that: the course knowledge system is firstly constructed by Bayesian Network and then the prior probability table of influence degree between nodes is obtained deductively through the learners' user profile and Bayesian Network; lastly, adaptive learning path suitable for different learners is generated according to learners ' ability diagnosing algorithm, so as to achieve adaptability learning.

### *A. Adaptive e-Learning system prototype:*

Adaptive e-Learning system prototype (Picture 1) can be generally divided into 3 layers: concept layer, relation layer and user view layer.

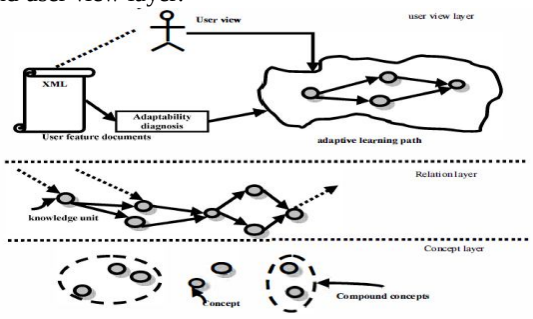


Fig 1: Adaptive e-Learning system prototype

Concept layer is the solid layer used to store concepts. Learning behavior is the recognition of concepts, and the concepts might be simple concept or concept unit through organizing or applying different concepts. Relation layer is

to describe the interrelations between concepts, take out the required concept or compound concept from the concept layer, add a layer of definition and become a knowledge unit, that is, to generate a generic learning path, and finally gather these knowledge units and form a course. The definition of relation layer is the cause and effect relation in the Bayesian Network. Prerequisite of concept is used to define which one is the father node, and the content of Conditional Probability Table is the joint probability distribution of each random variable in Bayesian Network. In user view layer, by comparing the general learning path generated by the second layer and the user profile, the adaptive learning path for different learners is then generated.

***B.Adaptability diagnosis design***

Adaptability diagnosis, known as the judge of learner' s competence, is to test students through adjusted test papers and to estimate students' competence and mastery of the knowledge in the field according to students' responses. It is an important basis for the system to organize the learning content dynamically, and it can happen at the start, in the end or in the middle of the learning process. The judge of students' learning competence is a critical step in adaptive e-learning system because it is the important basis that the system knows students' learning competence and cognitive competence. Without this basis, individual student' s learning needs cannot be known, let alone carrying out the adaptive learning according to students' needs.

In the aspect of adaptive diagnosis, the most widely used framework is based on the item response theory (IRT) [9][10]. This paper adopts the "three-parameter logistic model" of Logistic Model in IRT, and the mathematical formula is as follow [11]:

$$P_i(\Theta) = C_i + \frac{1 - c_i}{1 + e^{-1.702\, a_i (\Theta - b_i)}}$$

n the formula, P(Θ)is the probability of students with competence parameter Θ 's correct response to the test i. $a_i$ represents the discrimination of test i, bi represents its difficulty, and $C_i$ represents its pseudo-chance parameter.

***C. Adaptability navigation design:***

For each learner has their own characteristics, they have their own user profiles in adaptive e-Learning system. User profile is a "format" structure, and its format in this paper is XML. The structure is shown in Picture 3. It contains user' s different information, such name, learning objectives, learning state, learning competence and learning progress, etc. The adaptability navigation model in this paper is realized by generating different adaptability learning path through learner competence judge algorithm according to the user file.

Fig 2 is the item characteristic curve of " three- parameter logistic model" of three different tests, from which we can see that ai is the slop of the inflection point, and the larger the value is, the higher the discrimination of the test; bi is the 0 of the P/ 0) =0. 5, and the larger the value is, the more difficult the test is; Ci is the intercept of the characteristic curve, and the larger the value is, the easier it is for the testees to guess the right answer without concerning their competence. Therefore, in the process of adaptive diagnosis, test with higher discrimination, lower pseudo-chance parameter and moderate difficulty (test 2 in picture 2) is favorable. This paper adopts the test used in the system for a period of time, and the questions not according with the requirement were adjusted according to the statistic of accuracy rate of each question so as to simplify learners ' ability diagnosing algorithm.

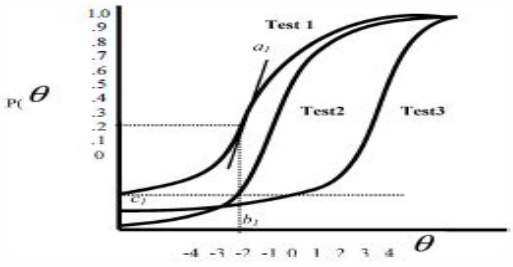


Fig 2: Item Characteristic Curve

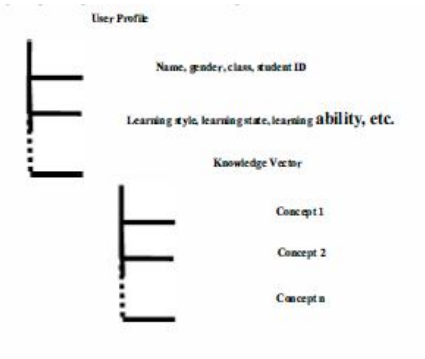


Fig 3: User Profile Structure

It constructs the adaptability navigation by using " Hidden Links" and " Bayesian Network" . In the "Hidden Links" part, the state of each node is decided through Bayesian Network, and then the nodes are removed according to "learning objectives" . Finally, the false path of the graph is adjusted the path and the adaptability learning path is generated. The pseudo-code algorithm of adaptability navigation is described in Table 1 as follow:

I: Initiate a empty set U.
2: Initiate a graph G(V, E) where V= { all nodes of a concept set}, E = {}.
3: for all node ViE V do
4: Initiate a ordered set P= { All require nodes of V}i.
5: if P isn't empty then
6: Put all pair of nodes (PhvJ into E where Pi E P.
7: end if
8: end for
9: Set states of nodes.
10: for all ViEVdo
11: Initiate a empty ordered set R.
12: if the level of Vi> learning objective then
13: Put Vi into U.
14: for all (Vi, V) where $V_j$E V, (v;, v) EE do
15: Put them into R and remove them from E.

16: end for
17: Initiate a empty setE '.
18: for all pair ($v_m$, $v_n$ € R do
19: for all pair ($v_x$, $v_y$) € E do
20: if $v_y$= $V_m$ then
21: Put (vx, vn) into E'
22: Else ,
23: Put (vx, vy) into E'
24: end if
25: end for
26: end for
27: E =E'
28: end if
29: end for
30: Generate a new graph G'(V- U, E).

1. Initialize U = empty set to store nodes to be removed
Define a graph G (V, E), the table V is a "node set" , E is "edge set" , and initialize a general course learning path into a graph.
2. Make a graph of general course learning path
3. Set States of Nodes i.e. Deduct students level in each concept node
4. Put all nodes with higher degree than learning objectives into U
5. Find all child nodes of the node to be removed
6. Find all father nodes of nodes to be removed & pull directed edge to all child nodes
7. After removing the nodes, the directed edges with father or child nodes shall be removed from E.
8. The finally generated graph G' (V-U, E) is the adaptability learning path.

## III. DESIGNOF ADAPATABILITY LEARNING SYSTEM

### *A. Overall design*

The adaptive e-Learning system designed in this paper adopts B/A/S model, namely, Browser/ Agent/ Server model (shown in picture 4). [t is a "thin client" model, and user uses the browser to surf the internet, having no more need of installing Setup on the client computer.

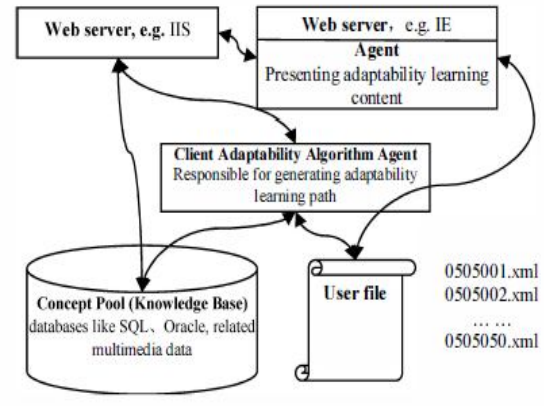


Fig 4: System Structure

By adopting B/A/S model, the system on the one hand provides a unified environment for e-learning, and simplifies the development, maintenance of system and the cost of user training; on the other hand, the functions of client and server can be strengthened by running some intelligent Agents.These agents are mainly developed through Flash ActionScript 2.0 to solve the problems like the integration, interexchange and demonstration of multimedia heterogeneous data and source data in e-Learning. For almost all the Internet browsers (IE, Safari, etc.) have installed the Flash Player ActiveX, the problem of demonstration of multimedia content in e-Learning is adequately solved. Meanwhile, these intelligent Agents can record users' learning process and revise XML user files, and generate adaptability navigation to present learners with adaptability learning content.

### *B. System function design*

Combining the modular programming idea in software engineering, the design of adaptive e-learning system modules abide by the rule of High Cohesion and Low Coupling. The system structure and function modules are as shown in Picture 5:

### *C. Design of business flow and dataflow*

As the core user of the system, students can participate in all the activities required by a course through the student adaptability learning system. The activities include course adaptability learning, progress test, referring to course blog, participating course discussion, submitting assignment and lab report, etc.

System function design:

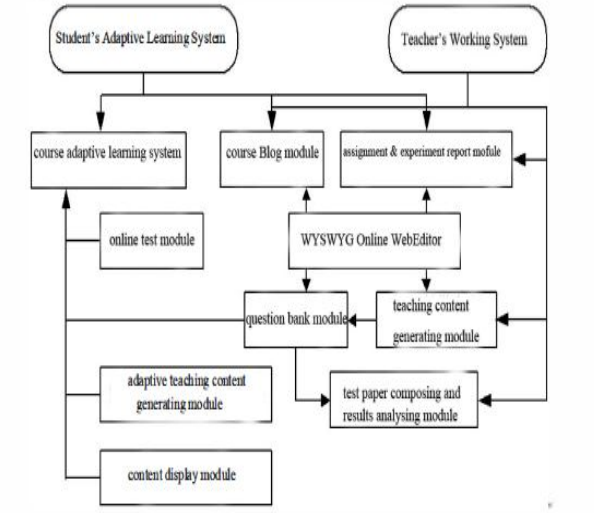


Fig 5: System Function System Division Chart

***a) Adaptability test flow:***

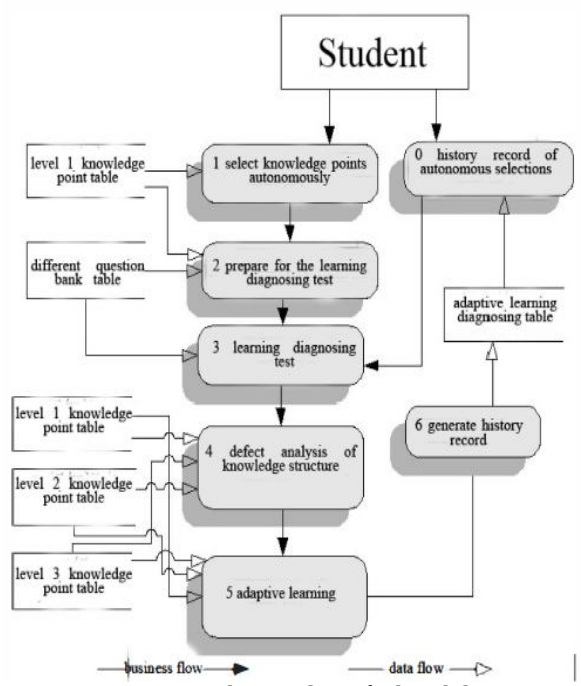


Fig 6: Business and Data Flow of adaptability test in adaptability e-Learning system.

Step 0: Autonomous choosing of history records
It is one of the starts of adaptability test, and the system login in Step 3 according to the history records in adaptability learning diagnosis table.
Step 1: Autonomous choosing of related knowledge points
It is one of the starts of adaptability test, and the system provides suitable level 1 knowledge points for learners according to "statistic condition of the questions belonging to this knowledge points in the question bank" in the level I knowledge points table.
Step 2: Preparation for learning diagnosis test questions
According to the statistic condition of corresponding questions belonging to the knowledge points in "Level I Knowledge Points Table" and distribution of multiple choice question bank table, true or false question bank table and questions related to this question bank, the system will select one question with difficulty of D in each knowledge point in accordance to the learner' s learning competence 0.
Step 3: Learning diagnosis test
Student answers, submits (initiatively or autonomously) in pre-set time (e.g. 2 mini question).
Step 4: Knowledge structure defect analysis
The system autonomously judge learning diagnosis data, analyze students' knowledge structure defects and learning competence, and organize, generate adaptability learning path (adaptability navigation) according to adaptability navigation construction algorithm.
Step 5: Adaptability learning
Students realize adaptability learning and make up the knowledge structure defect.
Step 6: Generating history record Corresponding history record is written diagnosis table.

***b) Progress test flow:***

Progress test is carried out during or at the end of the learning. The test during the learning aims to help students find out weaknesses through formative evaluation and strengthen their learning. Moreover, practice and test are learning methods. The test after learning is a kind of summary, and it affirms whether the students achieve the anticipated teaching objectives. The steps of adaptability e-learning system are as follows:
Step O: Preparation
If there are additions or deletions in the course question bank, or the attribute value of corresponding knowledge points alters, this step must be taken. Set the features like sequence numbers of corresponding knowledge points (of all the difficulties) in the question bank, the sequence numbers of high difficulty questions (except for those difficulties are "easy" ) of corresponding knowledge points, and the sequence numbers of lower difficulty questions (except for those difficulties are "difficult" ), so as to make the questions ordering. The corresponding statistic results shall be saved in the corresponding features of " Level 1 Knowledge Points Table" , "Level 2 Knowledge Points Table" and "Level 3 Knowledge Points Table" . It will enormously enhance the efficiency of test paper generating algorithm.
Step 1: Adding phase test and parameter consulting and revising
Teachers of related course can generate different phase test papers through adaptability e-learning system. The test editing method, test genre, question type, distribution of knowledge points, difficulty index, testee, pennit times, test opening time and test running time can be set according to needs, looked up and revised.
Step2: Setting of test paper generating strategies
Adaptability e-leaming system provides 3 kinds of tests,namely, course test (based on level I catalogue), unit test(based on level 2 catalogue) and knowledge point test(based on level 3 catalogue). Teachers can set different test organizing strategy table according to diverse test.
Step3: Test paper generating
After the test orgamzing strategy set, the computer will select corresponding test questions to generate a test paper in accordance to the requirements.
Step4: Test item choosing
The system will flexibly recommend phase test items suitable for different students according to their learning process and present learning competence value. The students can certainly choose all the phase test items in the present group (class and grade).
Step 5: Online test
Students answer and submit the test in preset-time (initiatively submit or automatically submit after the preset-time used up).
Step 6: Submit
Online test will be submitted automatically when the preset-time runs out, and students can also submit initiatively.
Step 7: Automatic grading and score displaying
The phase test paper is graded by the system itself, and the score is displayed in real time.
Step8: knowledge structure defects analysis
If the type of phase test is practice, the system will adopt adaptability algorithm to diagnose the learning, and analyze the defects in knowledge structure.

Step 9: adaptability learning
The system can acquire student ' s mastery of the knowledge in related unit according to the present phase test results. Based on the conditions, the system organizes, generates adaptable learning content, so as to realize adaptability learning and automatic question answering.
Step 10: generating history record and adjustment of teaching strategy analysis
The system automatically records students' each test result. Through referring to history record, teacher can analyse the scores of phase tests and know the teaching effect of relevant unit or knowledge points, the difficulty of the test, and adjust relevant content according to the analysis.

## IV. CONCLUSION

The rapid development of computer network brings great opportunities for the development of education. E-learning emerges and provides students with free learning environments, rich resources and broadens the time and space for teaching as well. There are many reasons to pursue adaptive e-learning. The potential payoffs of designing, developing, and employing good e-learning solutions are great, and they include improved efficiency, effectiveness, and enjoyment of the learning experience. In addition to these student- centred instructional purposes; there are other potential uses as well, such as online assessments. Ideally, an assessment comprises an important event in the learning process, part of reflection and understanding of progress. In reality, assessments are used to determine placement, promotion, graduation, or retention. We advocate pursuing the ideal via online diagnostic assessments. Tests alone cannot enhance educational outcomes. Rather, tests can guide improvement—presuming they are valid and reliable— if they motivate adjustments to the educational system. There are clear and important roles for good e-learning programs here. However, and as mentioned earlier, the current state of e-learning is often little more than online lectures, where educators create electronic versions of traditional printed student manuals, articles, tip sheets, and reference guides. Although these materials may be valuable and provide good resources, their conversion to the Web cannot be considered true teaching and learning. Instead of the page-turners of yesterday, we now have scrolling pages, which is really no improvement at all. Adaptive e-learning provides the opportunity to dynamically order the “pages” so that the learner sees the right material at the right time. There are currently a handful of companies attempting to provide adaptive e-learning solutions (e.g., see LearningBrands.com, AdaptiveTutoring.com, and Learning Machines, Inc.). Further, adaptive e-learning has become a rather hot topic in the literature recently. However, many of these are not concerned with adaptive instruction at all; rather, they are concerned with adapting the format of the content to meet the constraints of the delivery device, or adapting the interface to the content to meet the needs of disabled learners. Of those that are concerned with adaptive instruction, most tend to base their “adaptivity” on assessments of emergent content knowledge or skill or adjustments of material based on “learner styles”—less suitable criteria than cognitive abilities for making adaptive instructional decisions. We believe that the time is ripe to develop e-learning systems that can reliably deliver uniquely effective, efficient, and engaging learning experiences, created to meet the needs of the particular learner. The required ingredients in such a personalized learning milieu include rich descriptions of content elements and learner information, along with robust, valid mappings between learner characteristics and appropriate content. The result is adaptive e-learning, a natural extension of to the field of educational psychology.

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