CHAPTER 2: LITERATURE REVIEW

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This chapter presents the literature review of the thesis. Reviews are conducted on all the necessary areas that are relevant to our research work.
2.1 Introduction

In any academic curriculum, the assessment of students' knowledge about a particular topic/course is a very challenging one. Whether it is face-to-face classroom learning, distance and open learning, online learning or blended learning; the assessment process is very time consuming and a large number of human resources are required. Over the past few years with the applications of Information and Communication Technology (ICT), the traditional paper based assessment process is replaced by online assessment technologies. Various researches have been carried out to improve student’s learning ability by assessing the student’s knowledge online and giving some proper guidance. According to Harris and Bell, Online assessment is an entirely automated process of delivering and marking assessments using web or Internet resources. Bull and McKenna argues that compared with traditional assessment, it has many advantages, such as increasing the frequency of assessment, broadening the range of knowledge assessed, extending the range of assessment methods, increasing feedback to students and lectures, decreasing marking loads and aiding administrative efficiency. This chapter introduces different assessment techniques and explores strategies to overcome challenges in their design, development, and delivery in online environment.

Student modelling is an important issue in the design of an expert system for online assessment. Student modelling is an integral component of Intelligent Tutoring Systems (ITSs). An extensive literature review is conducted in the student modelling of the ITSs. This chapter focuses on computerised adaptive testing as a recent advent in
student modelling. It examines the major student modelling techniques which model domain-specific knowledge of the student.

Since the proposed expert system is a web based system, I have discussed the common issues associated with the design, development, and use of web-based ES from a standpoint of the benefits and challenges of developing and using them. The original theory and concepts in conventional ES were reviewed and a knowledge engineering framework for developing them was revisited. The benefits and challenges in developing and using ES are discussed by comparing them with traditional stand-alone systems from development and application perspectives.

2.2 Importance of Online Assessment

In these digital days of learning, in the academic course delivery and curricula, the teachers and the trainers always want to know whether their student knowledge assessment practices are appropriate or not.

In a traditional face to face learning environment, the students are assessed by conducting some kinds of unit test or term-end examinations. On the basis, how students have done in the examination, some grades are assigned to them and promotes to the next class. This is traditional learning. As we know that due to the increase in popularity of Open and Distance Learning (ODL), a huge number of students like to opt this type of education system. The main advantage of ODL system is that there is no age limit of the learners. It has been observed that the number of students in ODL system is increasing due to its flexible learning opportunities. But there are some disadvantages in the ODL system. These are: (a) physical
communication gap among the teachers and the learners; (b) assessment of students’ knowledge. But in case of traditional classroom face to face learning or ODL system, the main problem I have observed is related with the learners’ assessment policies we adopt. The solution is to adopt online assessment techniques. The advantage of using online assessment techniques in both the face-to-face learning and in ODL systems are:

(a) Instant feedback
(b) Easy individual and group feedback
(c) Monitor group process as well as outcomes
(d) Easy distribution to markers
(e) Less time marking
(f) Increased opportunities for practice and feedback

2.3 Computer Based Training (CBT)

Computer has been used as an educational and training tool for more than 30 years and its use has been spreading rapidly in all levels of education and training. During the 1960s, significant resources were invested in the development of Computer-Based Tests (CBTs). As far as expert systems are concerned, its methods and tools are being applied to straightforward expository systems as well as to learning environments designed with the intention of promoting learning by discovery.

The basic principle of CBT is the linear one that is a fixed-length computerised assessment process which provides the same number of items to each learner/examinee in a specified order. The result usually
depends on the number of items answered correctly. A linear type of CBT consists of some sets of easy and difficult test questions that are either randomly selected from a large test question bank or same for all learners/examinees. These types of CBT imitate only the traditional ‘paper-and-pencil’ test that is presented in the digital form. However, these types of CBT do not consider the question answering ability or knowledge level of each of the individual examinee.

2.4 Student Modelling

Student modelling can be referred as a process which represents several cognitive issues like evaluating the student’s performance, identifying and isolating the misconceptions, detecting student’s prior and acquired knowledge and defining personalised characteristics. The student model is primarily used in Intelligent Tutoring Systems (ITS) but its use has been extended to most current educational software applications that aim to be adaptive and personalised.

There are two major types of information which may be contained in a student model: model of domain-specific knowledge and model of individual, learner-related characteristics.

Learner-related characteristics can be conative such as wants, intentions and/or affective such as motivation, emotion and anxiety (Self, 1994). Examples include modelling motivation (Matsubara and Nagamachi, 1996) and modelling learning styles (Bull and Shurville, 1999). There has been relatively little attention devoted to modelling the learner’s state of such characteristics beyond domain knowledge and common misconceptions. As such, there is still a lack of standardised means of classifying these models. On the other hand,
there are established techniques for modelling student knowledge in relation to domain or course knowledge. In the development of ESOA, since we have to implement the student model, let us take a brief overview of different student modelling techniques in the following sections.

2.4.1 Scalar Model

The simplest form of a student model is a scalar model, which estimates the level of user knowledge of the course material by means of a certain integral estimate such a number ranging from 1 to 5.

2.4.2 Overlay Model

The main assumption underlying the overlay model is that a student may have incomplete but correct knowledge of the domain. The overlay model contains the student's knowledge as a subset of the expert or domain knowledge which reflects the expert-level knowledge of the subject (Figure 2.1). It works on the basis that students will learn the domain and gain knowledge through aspiring to become experts. The domain is decomposed into a set of elements and the overlay model is simply a set of masteries over those elements. Knowledge is represented and structured in the same way for both the domain knowledge and the student model, the difference being in terms of completeness. Knowledge representation techniques include rule-based representations and semantic networks. During student modelling, diagnosis takes place by comparing the student's knowledge with the domain knowledge and the difference is explained as the student's lack of skill.
This method is incomplete because only the lack of knowledge can be modelled. The main problem with the overlay model is that it assumes that a student’s knowledge can be merely a subset of that of an expert, which may not be the case. The domain model is usually represented in terms of atomic units, that is, a student either knows or does not know a certain unit. A student’s partial knowledge of a unit cannot be represented. Also, it does not represent any knowledge or beliefs, such as misconceptions, that the student might have that differ from those of the expert. That is the reason why many adaptive and/or personalized tutoring systems perform student modelling, combining overlay model with other student modelling approaches like stereotypes, perturbation and fuzzy techniques.

2.4.3 Stereotypes Model

The motive of stereotyping model is to cluster all possible users of an adaptive system into several groups according to certain characteristics.
that they are typically shared. Such groups are called stereotypes. A Stereotype normally contains the common knowledge about a group of users. A new user is assigned into a related stereotype if some of his/her characteristics match the ones contained in the stereotype.

2.4.4 Differential Model

It is seen as an expansion to the overlay model. It divides the student’s knowledge into two categories: knowledge that the student should know and knowledge the student could not be expected to know (see Figure 2.2).

![Diagram showing Domain Knowledge, Expected Student Knowledge, and Overlay Student Model]

**Figure 2.2: A Differential Student Model**

2.4.5 Perturbation Model

The perturbation model approach, also called the buggy model, goes beyond inferring what the student knows and does not know about a domain by inferring as well, any faulty knowledge or misconceptions that the student might possess. The perturbation student model, which represents the student’s correct and faulty knowledge, is considered a
subset of both the domain knowledge and buggy knowledge (see Figure 2.3).

This approach combines the standard overlay model with a representation of faulty or buggy knowledge. The domain or expert knowledge is first represented and then augmented with explicit knowledge of possible misconceptions of the student. This explicit knowledge is known as buggy knowledge and allows a more sophisticated diagnosis of the student's state of knowledge than can be accomplished with a simple overlay model. Subsequent remediation goes beyond filling in gaps in the student's knowledge where the tutor must identify and eliminate the student's misconceptions as well as adding the correct conceptions to the understanding of the student.

2.4.6 Genetic Graph Model

While the first five models described above capture a snapshot of the current knowledge of the student, the genetic graph (Goldstein, 1982) captures an evolutionary process of the student's knowledge over time.
It is a type of semantic network which represents the expert's conception of the domain.

The nodes of the graph represent the student's knowledge and the edges represent the expert's view of how learning occurs between nodes. A student's learning behaviour is shown by a particular learning path in a sequence which corresponds to the genetic graph's partial ordering and this learning path forms part of the student model.

Here, student modelling is still an overlay technique where the student model is a subset of the domain knowledge. The main difference between the standard overlay technique and the genetic graph is that the latter is not only concerned with maintaining what the student knows but also how his knowledge is acquired over time. This is represented by the student's learning path which evolves as he progresses in his learning.

2.4.7 Bounded Model

A bounded model (Elsom-Cook, 1988) can be considered as a variation of an overlay model. This technique moves away from representing knowledge to working in terms of beliefs about the student's knowledge. The idea is that, rather than attempting to build an exact student model, the student's knowledge is represented by fuzzy bounds. By observing student behaviour, the system maintains a confidence interval around the lower and upper bounds of the student's knowledge. Standard machine learning techniques are used. The lower and upper bounds are obtained through inductive reasoning. Then, on the basis of the system's domain knowledge, deductive reasoning is used to generate predictions and problems are generated to test these
predictions. Bounded models can be more tractable to build than exact models but subsequent remediation is less precise.

2.4.8 Constraint Based Model

A constraint-based model (Ohlsson, 1994) features as being computationally simple. It does not require large empirical studies for constructing a bug library, nor a runnable expert model or an ideal student model. No computationally expensive inference algorithm is required – simple pattern matching is used. The domain knowledge is elicited through task analysis and is represented as a set of constraints that capture the central concepts of the domain. The student model is the set of constraints which he violates. These violated constraints become candidates for concepts which the student does not know and is used to guide remediation or feedback. An example of this approach is the SQL Tutor (Mitrovic, 1998) which elicited from an expert around five hundred constraints.

Constraint-based modelling does not prescribe a particular tutorial strategy. It ignores the student’s problem solving strategy and is thus able to monitor free exploration and to recognise creative and novel solutions as correct. Ohlsson (1994) coined the term radical strategy variability which claims that a student has several strategies at each moment in time, and he may switch between them on a problem-by-problem basis. In the face of such inconsistencies or contradictory behaviour observed in student solutions, constraint-based modelling approach fared the best in tackling this problem while the bug library and machine learning techniques fared the worst.
2.4.9 Machine Learning Model

Machine learning is a technique of Artificial Intelligence which develops computational theories of learning processes and builds machines which learn. Gilmore and Self (1988) examined the potential of machine learning for building student models. A bottom-up approach is adopted which first identifies a solution path that leads to the final answer and then machine learning is applied to perform reconstructive diagnosis in order to construct a procedure that generates that path. While this technique does not require empirical research to construct a bug library, the computational complexity involved can even be higher than that of the bug library technique.

2.5 Computerised Adaptive Testing

Computerised adaptive testing or CAT (Wainer, 1990) is a recent arrival into the scene of student modelling. With its roots in psychometric measurement, CAT is characterised by the efficiency and accuracy at inferring a student’s knowledge in a domain with the minimum number of problems. The student is presented with problems of appropriate difficulty. This has the advantage of reducing test anxiety, sustaining the motivation of students during testing, and more importantly, of reducing the overall testing time. An interesting analogy between measurement within a tutoring system and psychometric measurement was made by Frederiksen and White (1990).

Two major techniques of computerised adaptive testing have been particularly influential in their application in student modelling. They are the Item Response Theory or IRT (Wainer and Mislevy, 1990) and the Knowledge Space Theory or KST (Falmagne et al., 1990). These are
discussed in more detail in Sections 2.5.1 and 2.5.2. CAT can be viewed as an overlay technique. This approach is based on the two major techniques mentioned above; the domain knowledge is represented as a problem domain which contains problems or classes of problems for a particular area of syllabus. For example, in the KST approach, the domain may be represented by a directed graph of nodes where each node represents a problem or a class of problems and the edges represent the relationship between the nodes. The student model is a subset of the graph and represents the student’s knowledge as a particular path on the graph. Other works have represented the domain knowledge to include not only problems or classes of problems but also concepts and skills. Examples include granularity hierarchies (Collins et al., 1996) and curriculum hierarchies (Huang, 1996).

The following section is devoted to discussing adaptive testing in detail.

Traditional fixed-length, pencil-and-paper fixed-item testing, or FIT for short, remains the major testing strategy in educational and training settings. FIT includes the administration of a fixed set of questions to a student population. Any examinee is expected to answer all questions within a fixed period of time. There are questions with predefined order but an examinee does not need to follow that order while answering. He may skip some questions in between and return to them later. As this type of testing would be for the examinees of all capabilities within a population, therefore, there may be relatively few questions which are of the appropriate difficulty for any one examinee. Questions may be too difficult for the weak examinee, or too easy for a good examinee. As a consequence, large numbers of questions may be needed to obtain an acceptable degree of precision. Also, questions are arranged according to the order of difficulty. This may work well for a less skilful examinee
as he will be able to answer the earlier questions which are easier before reaching the more difficult ones. For a good examinee, however, he would have to go through the easier ones before reaching the more challenging questions. In both cases, there is a possibility of unnecessary noise such as guesswork and careless slips. For the less skilful student, anxiety may occur when he attempts the more difficult questions and he may attempt to solve them through guessing. For a more skilful student, boredom may occur when he goes through the easy questions and this wastes time and may increase the possibility of noise mainly caused by careless errors or slips.

For the same purposes, a useful variation would be for all examinees to take tests that are individually suited to their own abilities. With the advent of more powerful and affordable desktop computers in the 1980s, it became possible to implement computerised adaptive testing, or CAT for short, in educational and training settings. The strength of CAT lies in asking only enough questions for assessing a student in a subject domain and in its ability for ranking all examinees on the same continuum even when the examinees do not share any test items in common. CAT is defined as a sequential form of individual testing in which successive items in the test are selected based on an algorithm which adapts the test to the specific characteristics of each examinee. As mentioned earlier, the goal of CAT is to use the least number of questions necessary to determine, with high accuracy, the level of performance of the examinee (Welch and Frick, 1993). When an examinee is able to answer the current question correctly, he is given a more difficult one or an easier problem is given to solve when he has answered the current one incorrectly. In this way, an examinee is offered with problems of appropriate difficulty throughout the test. This
careful tailoring and selection of problems result in greater accuracy of the assessment with only a handful of properly selected items as well as reduces the overall testing time.

An adaptive test is generally computerised, even if a manual method such as the self-scoring flexi-level test can be used which is described by Frederic Lord in 1971, a description of which is given by Thissen and Mislevy (1990). The main characteristics of CAT are:

- The test can be taken at the time convenient to the examinee; there is no need for mass or group-administered testing, thus saving on physical space.

- There is no need for any two tests to be identical for any two examinees as each test is tailored to an examinee, and this diminishes the possibility of copying.

- Each question is presented on a computer screen once at a time.

- Once an examinee confirms his answer, he is not able to change it.

- The examinee cannot skip questions and return to a question which he has confirmed his answer previously.

- The current question must be answered by the examinee while proceeding to the next one.

- The selection of each question and the decision to stop the test are controlled dynamically on the basis of the answers of the examinee.

Some examples of the use of CAT include three of the world’s most widely used college and graduate admissions tests which are dealing the pencil-and-paper formats for CAT (Educational Testing Service, 1999; Oseas-Europe, 2000). These are Graduate Record Examinations
(GRE®) General Test (GRE, 2000), the Graduate Management Admission Test GMAT® (GMAT, 2000), and the Test of English as a Foreign Language TOEFL® (TOEFL, 2000). Other major moves include Microsoft® for the Microsoft® Certified Solution Developer (MCSD) credential (Microsoft, 2000), and COMPASS®/ESL which measures students' mathematics, reading, and writing skills on demand (COMPASS, 2000).

A variation of CAT is self-adaptive testing, or SAT for short, where an examinee can work out some control over the sequencing of problems. The examinee, rather than a computerised algorithm, chooses the difficulty of the next problem to be presented (Rocklin, 1994). In a study carried out by Rocklin and O'Donnell (1987), SAT was compared against the more traditional FIT. Participants completed a self-report of text anxiety and were randomly assigned to take one of the three tests of verbal ability. Anxiety is related with decrements in academic performance and is characterized by a situation where a student claims to have mastered the course material before the test or examination but is not able to perform satisfactorily during the test, only to remember the material with complete clarity after it is too late (Covington and Omelich, 1987). The study showed that SAT not only led to higher ability estimates but also minimised the effect of test anxiety without any overall loss of measurement precision.

2.5.1 Item Response Theory

Item Response Theory (Wainer and Mislevy, 1990), or IRT, is a statistical framework in which examinees can be described by a set of ability scores that are predictive, linking actual performance on test
items, item statistics and examinee abilities. IRT was first proposed by Lord (1980) and is well explained by Wainer (1990). There are web-based tutorials on IRT (Rudner, 1998). True to the goal of CAT in general, IRT-based adaptive testing systems have been shown to significantly reduce testing time without sacrificing reliability of measurement (Weiss and Kingsbury, 1984).

2.5.1.1 Domain Description

In IRT, each item is associated with three parameters (a) the difficulty level, (b) the discriminatory power and (c) the guessing factor. The difficulty level refers to how difficult an item is; the discriminatory power refers how well the test item discriminates students of different proficiency and while the guessing factor is the probability that a student can answer the item correctly by guessing.

Here, an item pool must undergo content-balancing and item calibration. Content-balancing is used to ensure no content area is over-tested or under-tested. Item calibration is used to estimate values for the item parameters. This process is expensive as it involves large-scale empirical studies, usually based on a minimum of 200 to 1000 or more students. An effort to avoid major empirical studies for item calibration is the work by Huang (1996) whose CBAT-2 algorithm uses a machine learning procedure to generate content-balanced questions based on a specific part of a course curriculum.

2.5.1.2 The Problem Progression Strategy in IRT

At the start of the test, the algorithm has an initial provisional proficiency estimate of the student and this is denoted by \( \theta \). This
specifies an initial item which is selected from the item pool. The selected item is aimed at providing the most information about the student. Once the student provides an answer for the selected item, a new proficiency estimate, $\theta$, is calculated together with its confidence level. It is based on whether the student’s answer is correct or incorrect, the old $\theta$ and the item parameters. If the confidence level of $\theta$ reaches a designated level, or when some predetermined number of items has been administered, the test terminates. Otherwise another item is selected for the student, and the test continues.

2.5.2 Knowledge Space Theory

Another strand of development in adaptive testing is based the Knowledge Space Theory, KST for short, (Doignon and Falmagne, 1985), (Falmagne et al., 1990). Examples of applications include a web-based, domain-independent system called RATH (Hockemeyer and Dietrich, 1999), a web-based system for the domain of mathematics called ALEKS (Doignon and Falmagne, 1998) and a general purpose system for testing and training called ADASTRA (Dowling et al., 1996).

2.6 Current Software Tools of Online Assessment

A large number of software tools are available which can be used for the assessment of student learning. These software tools can be categorised into two classes (a) proprietary software and (b) free and open source software. Let us discuss them briefly.

2.6.1 Using Proprietary Software

(a) Blackboard: It is a widely used LMS all over the world. The system has a module that handles assessments, but the types of assessment offered are relatively simple ones like true/false and
matching. The system also offers a proprietary programming interface which allows developers to create new types of assessments for use within Blackboard only. (BlackBoard, 2004)

(b) **PLATO Learning:** It is a company that offers an LMS. In terms of assessment, its great strength lies in the fact that it has a library of almost 200,000 prepared problems that can be directly incorporated into classes. But the system uses some basic types of assessment techniques. (Plato Learning, 2004)

(c) **SumTotal:** It is a well-known vendor of instructional system. Their system, TotalLMS, offers a great deal of functionality associated with an LMS including powerful assessment capabilities. But these assessment capabilities are still limited to the most basic types of problems. (SumTotal, 2004)

(d) **Wondershare Quiz Creator:** It is a software tool which offers flash/web based interactive interfaces for assessing student learning activities. With this assessment tool, question bank of different subjects can be designed. The question type includes multiple choice, true-false, matching and fill in the blanks. The tool offers instant feedback to the learner on every attempt of the question. The tool offers a cost-effective, easy way to implement computerized assessments that not only measure knowledge, skills and attitudes but also enhance the learning process of the students. (Bertea et al., 2012)

(e) **Adobe Captivate:** It is industry-leading e-Learning authoring software for rapidly creating and maintaining interactive e-
Learning content. The tool can assess learner performance by monitoring learner progress by embedding a wide variety of interactive ‘test me’ quizzes. The quizzes can be easily published to leading SCORM- and AICC-compliant Learning Management Systems and track key performance metrics. (Captivate, 2012)

2.6.2 Using Free and Open Source Software

A large number of free and open source learning management systems are available which include some module or component for implementing online assessment of student learning. Moodle is an open source, easy to extend and customize, Learning Management System (LMS). It is also called as a Virtual Learning Management System. Along with comprehensive online documentation, there is lot of support available from the active online community regarding using/customizing/extending Moodle (Archana Rane et al.). “Quiz” module in Moodle, provides an online assessment interface for assessing student learning. Moodle’s quiz module is one of the most complex pieces of the VLE. There are a large number of options and tools in the quiz engine, making it very flexible.

The benefits of Moodle e-assessment for learners are as follows (O'Rourke, 2010):

(a) The learner is provided with instant assessment scores.

(b) The grade book logs all assessment scores for viewing at any time and gives a real time view of learner progress.

(c) Feedback may be provided for each question, where appropriate, to give pointers to students and aids in the learning process.

(d) Adaptive testing is provided for in Moodle whereby the learner may attempt an assessment many times but loses some marks on each
(e) Assessments can be undertaken off-campus for continuous assessment wherever appropriate to encourage independent learning.

(f) Assessments can be provided in any discipline or subject (Engineering, Science, Business, Humanities or any other) as the system is completely flexible.

(g) An on-screen timer during the assessment informs the learner how much time is remaining.

I have successfully customized Moodle and deployed in a GNU/Linux based server in the Institute of Distance and Open Learning, Gauhati University, Assam, India. The server is connected with two computer laboratories in a LAN containing 100 computer systems. Classes are conducted online within the campus LAN. Teachers give the educational resource to the students and student can get these learning resources instantly by logging into the Moodle LMS. Using this LMS, teachers can monitor each and every activity of the students. At the end of a lesson, using the quiz module, some online tests are being conducted to assess the knowledge of the students. At the end of a test, students immediately get the result of the test and can review the test, i.e. their correct/wrong answers. The test results are automatically published in the respective course page using the ‘Quiz Result’ block of the Moodle.

Efront is another popular open source learning management system. The system also includes an interactive module for student assessment purpose. The teacher can design individual set of self-assessment tests (multiple choice/true-false) for the learner. The student can take these
tests anytime and the module provides instant feedback after each attempt of the test.

The main demerits of the assessment module of both the LMSs are:

(a) No consideration of learner’s academic history
(b) In a particular self-assessment test, though each learner gets a new question randomly at each attempt, actually the questions are delivered from the set of the fixed number of questions only, i.e. if the question set for a particular self-test contains 50 questions, the questions are delivered randomly to the learner from the 50 questions only.

2.7 Research in Online Assessment

Iahad, Noorminshah, et al. (2004) presents the evaluation of an online test based on a case study of an e-Commerce course offered by the Computation Department, University of Manchester Institute of Science and Technology (UMIST). The main aim of the online test is to provide rich feedback to students, which is one of the requirements of the learner-centered learning paradigm. The online test, in the form of multiple choice questions, provides feedback through automatic grading, providing correct answers and referring the students to the learning content which explains the correct answers.

Hatzilygeroudis, Ioannis, et al. (2006) present an adaptive and intelligent web based educational system that uses AI techniques for personalized assessment of the learners.

Ranganathan et al. (2010) proposes an assessment test called Bloom’s Online Assessment Test (BOAT) for a distance education course on the basis of Cognitive learning based on Blooms Taxonomy. By using
Bloom’s Online Assessment Test (BOAT) proposed in the paper, educators can assess students on multiple learning outcomes that are aligned to different objectives of their course as they seemed fit.

Uday Kumar, M., et al. (2011) presents the system architecture for applying intelligent methodologies to online assessment that adapts to the examinee’s ability level.

2.7.1 Case Study 1: MIND Online Evaluation System (OES)

MIND OES is a product for online examination with key features like question bank, time control, security etc. The needs of OES was raised due to the fact that conducting exams, checking them and compilation of results take up lot of time in any organization; also different types of exams have to be designed for different purposes. Recording of exam results and controlling of examination procedure is also a time consuming job. Organizations also conduct opinion polls from time and time for various purposes and conducting these polls and then analysing the results is very tedious job and need lot of manpower and time. Thus a need exists which can make these tasks easy and manageable with least amount of manpower and time.

MIND came out with the solution to design and build an Online Examination System (OES) in order to provide a cost effective solution to organizations for conducting examinations. Its key features are:

**Question Bank**

- Questions with varying complexity can be included in different exams from a question bank and assigned to user as per the level.
- User defined examinations and polls.
- Questions from various topics can be included
Control over time

- Does not allow user to give examination after the defined time limit.
- Stopwatch is displayed so that user can manage the time during the examination.

Security

- Robust security system takes care that no unauthorized user can have access.
- User can only see his own result but an Administrator can see the result of all candidates.

Exam & Grading

- Examination questions were compiled based on pool of questions from question bank.
- Questions were from varying complexity.
- Grading was done when examination completed or student has answered all questions.

Other features

- Report Cards are generated so that user can immediately view the result.
- User having options to move back and forth while taking the examination.
- MIND makes use of the following technical environment to build the OES:
  - Developed using Java, jsp and servlets
  - Uses SQL Server as database
  - Browser based client
The key benefits of OES are:

- Saving of resources both manpower and time
- Better organization and control
- Better security options.
- It can be deployed on web and used by organizations conducting online courses.

OES works as an online examination system. It comprises of a question bank, which keeps questions with varying complexity from various topics. However, users or lecturers who need to create an examination are required to manually compile the questions based on pool of questions from question bank. Grading was done when exam completed or student has answered all questions. The grading was solely based on traditional marking strategy. Grading will not be based on level of difficulty and student will be graded based on how well they have performed in the exam or how many questions they have answered correctly.

2.7.2 Case Study 2: ExamManager

ExamManager is a web-based examination/assessment system. Exam Manager enables students to review old and new examinations setup by their lecturers, take a graded quiz to test themselves, setup their own review examinations and quizzes from a database of questions in the subject category of their choice and review their own performance and scores.

On top of that, Exam Manage allows lecturer to create multiple-choice questions. User can add pictures, case studies, and explanations to the questions. Faculty users can either create their own questions or use
the questions that already exist in the question bank. Faculty users can determine how much time a student will have to complete the examination. They also control how many times students are allowed to take an examination. Faculty users have the option of hiding grades from students when they are done taking a quiz.

Once an examination is published, a student can use it as a study tool or an assessment tool.

**Study tool:** When reviewing an examination, the student will get immediate feedback on whether the selected answer is correct. An explanation page is linked to the question, providing students with study references or further information on the question. Students can also generate random examinations by selecting the category, difficulty level(s) and number of questions they want to be tested on.

**Assessment tool:** When students take a timed exam, they are only allowed a specific amount of time that has been set by the faculty. The students will not be able to see the questions' explanations nor to get immediate feedback. When the examination is ready to be graded, students will be given the option to go back to the examination to answer questions left blank.

Once students have taken the exam, ExamManager scores their tests immediately. Faculty users can choose to hide the examination score from students.

As compare to OES, ExamManager provide more flexibility to its users by providing study tools and assessment tools to its students. Once students have taken the examination, ExamManager scores their tests immediately. Obviously, student will be graded only when they have
answered all the questions. The questions are not be properly categorized into various level of difficulty. Student will be graded based on how well they have performed in the examination or how many questions they have answered correctly.

2.7.3 Case Study 3: Web-based Adaptive Testing (WAT)

Web-based Adaptive Testing is an online assessment system which has a module called "Test Module" that can generates questions adaptively, based on the student’s ability and also calculates the results. This system is able to assess the student’s knowledge based on his/her abilities to answer the questions, given in the form of quizzes mainly multiple choice and true or false.

The architecture of WAT is based on simple client-server architecture. A Java applet is downloaded onto the client’s machine, where the questions will be set to the students. Once the student answers the question, the applet sends the reply back to the server to calculate the result and send the next appropriate question. The questions are selected from various topics set by the teacher/author, who is in charge of the system. There are 3 difficulty levels and the teacher sets these difficulty levels, based on their difficulty. Initially, the student is given a pre-test, which is nothing but basic concepts about programming and computers. These questions itself will be in random so as to eliminate cheating. The scores obtained from this pre-test will be used as the starting estimated ability value. This pre-test is given to give equal opportunities to students when they start the actual quiz session.

2.7.4 Case Study 4: Architecture Tutor

It is an intelligent tutoring system developed at Azusa Pacific University. Functional concept graph is applied as an assessment approach in the
system. A set of nodes are being defined in the functional conceptual graph. Each node corresponds to each question in the system. Each node of the graph is associated with a value. Each node is corresponding to a question with an associated value. Typically, if a node consists of a number of child nodes, this node will have a higher value than its child node. If a student is able to solve a problem involving more concepts (more nodes in the graph) about a subject, he or she should have a reasonably good understanding of the subject. This does help in assessing the student's understanding of a certain subject.

2.8 Web Based Expert System

The early applications of expert systems were standalone, based on mainframe, AI workstations or PC platforms. Later came the LAN-based distributed applications. Despite their commercial success, Grove (2000) pointed out that several problems and limitations are associated with traditional ES applications:

- Knowledge bottleneck: It is difficult to acquire knowledge from different sources. Experts are often unable to express explicitly their reasoning process.
- Performance brittleness: An ES is limited in its coded expertise, which relates to a narrow domain and the ES therefore performs poorly outside its boundary.
- Availability: Having the expertise provided by an ES at the place and time where it is needed is a problem when limited to the use of a stand-alone system.
• Software distribution: Updating the software and interface requires many separate installation and upgrades over time. This is often beyond the competence of the users.

• Communication between distributed applications: A lack of common protocols for knowledge transfer tends to discourage designs involving co-operation or dynamic information sharing.

Power (2000) argued that rapid advances in Internet technologies have opened new opportunities for enhancing traditional ES. Internet technology can change the way that an ES is developed and distributed. For the first time, knowledge on any subject can directly be delivered to users through a web-based ES. Since its main function is to simulate expertise and distribute expert knowledge to non-experts, such benefits can be greatly enhanced by using the Internet. However, few web-based ES have been offered and analysed to shed light on the methodology and challenges of developing them (Potter et al., 2000) and (Riva, 1998). This is all the more surprising when commercial ES development tools such as EXSYS CORVID™, XpertRule Knowledge Builder™ and JESS have been extended to offer web-based delivery.

2.9 Literature of Web Based Expert System Applications

Grove (2000) provided some examples of web-based expert systems in industry, medicine, science and government and claimed that “there are now a large number of expert systems available on the Internet.” He argued that there are several factors that make the Internet, by contrast to stand-alone platforms, an ideal base for KBS (knowledge based system) delivery. These factors include:
• The Internet is readily accessible.

• Web-browsers provide a common multimedia interface.

• Several Internet-compatible tools for KBS development are available.

• Internet-based applications are inherently portable.

• Emerging protocols support co-operation among KBS.

Grove also identified several problems in the development of web-based KBS:

• Keeping up with rapid technological change to servers, interface components, inference engines, and various protocols; and

• Reducing the potential delivery bottleneck caused by communication loads and a limited infrastructure.

### 2.10 Case studies of web-based expert systems

#### Case 1: WITS

WITS, a web-based intelligent training and support system, was developed for providing training and intelligent support for small and medium sized enterprises (SMEs) in the use of information and communication technologies. It was a pilot research project funded by the European Commission's Leonardo Da Vinci programme and was inspired by statements that lack of adequate skills and knowledge are major barriers that SMEs exhibit in successfully adopting and running e-commerce and e-business. As a result, there is an emerging need for
better education and decision support for SME managers who are eager to embrace the technology and afraid of being left behind. WITS-advisor is the more important component; it can be regarded as a web-based ES. WITS is a client side ES without server-side data processing. It was easy to develop and can be used by anyone with Internet access and a web browser. The web-based ES made the evaluation and implementation of WITS easier than a conventional ES. There is no need to install the system in advance. It is easy to collect feedback. Visitors can be easily traced and analysed. By collecting information, it was possible to profile the users and determine the value of the system. Compared with traditional ES development tools, the web design software simplifies the user interface design. HTML-based user interfaces allow the incorporation of rich media elements. Also, the WWW helps in acquiring the knowledge needed in constructing the knowledge base. Any knowledge updating and maintenance can be handled centrally. Useful links are incorporated to help the user understand and interpret the ES recommendations. (Duan et al., 2005)

**Case 2: Fish Expert**

Fish-Expert is a web-based ES for fish disease diagnosis developed in China. This system can mimic human fish disease expertise and diagnose a number of fish diseases; it has a user-friendly interface. It contains a large amount of fish disease data and images used to conduct online disease diagnosis (Duan et al., 2002).

**2.11 Web Bases ES: Benefits and Challenges**
Duan et al. (2005) pointed the benefits and challenges of web based ES from different perspectives: technological, methodological, and applications. These are:

(a) Knowledge acquisition: The impact of the Internet on knowledge acquisition can be profound. Firstly, it provides another valuable knowledge source. Secondly, it makes knowledge elicitation from the domain expert possible at a distance. Thirdly, as Basden (2000) argued, the users can be closely involved in the selection and generation of the knowledge. However, these benefits bring with them problems and challenges including dealing with information overload, effective knowledge mining techniques, locating and verifying online experts, filtering knowledge, managing conflict when several online experts are involved, and security and reliability consideration.

(b) Knowledge representation and inference: Traditional development methodologies, tools, and techniques that work effectively in a stand-alone environment may not work well in a web situation.

(c) Knowledge validation: The knowledge validation, verification, and testing processes are likely to be one of the most useful additions to ES development. Users can directly submit their test cases or provide feedback to system developers via the Internet. Alternatively, the knowledge base can be uploaded for validation and be accessed directly by users. However, this approach needs a centrally managed validation process.
Generic online debugging tools would be welcomed by developers.

(d) Explanation and justification: One of the distinguishing features of an ES is its ability to explain and justify results. This function is enhanced by using Internet technology. It is also possible to receive explanation and justification from a human expert via the Internet. Therefore, future web-based ES shells could have built-in functions to facilitate online real time communications.

(e) System evaluation, implementation, and maintenance: From the users’ point of view, systems can be easily accessed globally; their locations are irrelevant and no installation is needed at the users’ location. Any updating and maintenance can be carried out centrally. Users’ feedback can be collected via online feedback forms for later analysis. Web-site analysis tools can be installed to trace the number of visitors and their behaviour; this is not normally possible with traditional ES. As the system can be operated at the site of the originators who are responsible for it, its maintenance, upgrading, and monitoring can be more effective and efficient.

(f) Web-based ES development tools: Traditional ES were developed for stand-alone computers. However, many shells do not support the openness and interoperability required for deploying ES over a wide area network (Sedbrook, 1998). Unfortunately, the web was originally conceived as a document distribution infrastructure and any attempt to use it
for distributing expert systems must cope with difficulties. Some web based ES tools are commercially available, but no formal evaluation and comparison of different ones has been conducted.

2.12 Conclusion

There are a few web-based education systems that being reviewed in this chapter. However, we could not found any literatures with the application of expert system in the online assessment of student learning. The ESOA that I propose clearly fits into the family of these stand-alone or web-based education/testing systems which were designed earlier. The principles of CAT and ITSs influenced my system design the most.