**CHAPTER ONE**

**INTRODUCTION**

* 1. **Background of Study**

Nowadays, the need to education is unlike any period before because the increasing advances in technology and science demand people who continuously learn and update their knowledge repertoire. Learning is not, similar to the past, limited to school days, and people need to have access to new or previously learned information at any time and place. Less than fifty years ago, such unlimited access to information seemed like a fancy and untouchable dream because education and learning were tied to knowledgeable people and instructional materials, and such people or materials were only accessible in specific places and times.

The emergence of computer and internet technologies; however, realized this dream. The first and most important thing they did was making information accessible to anyone who had access to them. Internet, as it is today, emerged round 1980’s and it quickly spread around the globe. It enabled its users to have access to others’ information, contribute to it with their own information, and be in contact with other users. In parallel, the advances in computer technology brought about cheap and high-speed personal computers and mobiles and soon, many schools, offices, and homes were equipped with them. They enabled people to access this large pool of information from any place and in any time.

Apart from technology progress, research in the field of human learning widened the knowledge of educationists and psychologists beyond the Behaviourist views of learning, and learners were confirmed to be more than passive receivers of information and respondents to environmental stimuli. In fact, the Cognitivist and Constructivist theories of learning showed that learners have the capacity of processing the information and building their individual knowledge bases, and they verified the importance of tailoring instruction to the needs of individual learners rather than prescribing a one-size-fits-all approach.

Additionally, the pioneering research by Bloom demonstrated the superiority of one-to-one over group instruction with outstanding results (Bloom, 1984). Bloom conducted experiments with different groups of learners in different learning situations and concluded that the ideal form of instruction is when an instructor instructs a person-or two to three people-rather than a group of people. The reason is that good instruction is not only a matter of conveying information, but also adapting the instruction to individual learners. A reality that is better realizable in one-to-one learning conditions. However, one-to-one tutoring has always been hard to realize in real-world educational setting due to the large difference between the number of instructors and learners and the high costs of providing one instructor for each learner.

Such scientific findings and technology advances, coupled with the emergence of Artificial Intelligence (AI), triggered the idea of designing technology-based instructional machines which are intelligent enough to adapt their instruction to learners in order to provide the benefits of one-to-one tutoring. The use of machines and computers for instructional purposes was already a mainstream at the time of AI emergence, but was limited to static and inflexible systems which were not intelligent and adaptive. After AI came on the stage, numerous systems with different purposes, theoretical backgrounds, architecture, and under different titles were designed and developed, and while some did not acquire much success, others have been quite successful in some domains.

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

Adaptive learning makes content dynamic and interactive, placing the student at the centre of his or her individual learning experience.

* 1. **Statement of The Problem**

Due to the different intellectual capabilities and entry knowledge of students, adoption of a "one-size-fits-all” method for presenting course modules to different students is grossly inadequate. The Information Technology has provided a platform to be leveraged to overcome the challenge, this is to be demonstrated in this project by implementing an adaptive learning environment.

* 1. **Aim and Objectives**

The aim of this project is to implement an intelligence based adaptive web educational system.

The objectives are:

1. To prepare a sample modularized course for the system
2. To implement an open source Adaptive knowledge based system.
3. To evaluate the effect of the adaptive system on learner’s speed of courseware completion and on learning.
   1. **Methodology**
4. A part of the CSC427 course (Computer Networking) would be modularized and adopted.
5. The functionality of an Adaptive Learning Environment and an authoring tool would be explored and implemented and the course modules would be designed using the authoring tool and presented using the Adaptive Learning Environment.
6. The effectiveness of the system would be evaluated by administering usability questionnaires.
7. A learning management system would be improved upon for efficient use.
   1. **Literature Review**

Different adaptive learning engines have been used to build adaptive learning systems, an example of this engine is the GRAPPLE Adaptive Learning Engine(GALE), Online Course Tool for Adaptive Learning(OCTAL)

Some of these systems are ‘Dreambox Learning Platform’, ‘edX Learning Platform’, ‘Knewton Adaptive Learning Platform’.

* 1. **Significance**

This project has various significances to both the lecturer and the student, one significance of the system to the student is that an adaptive system makes learning comfortable for students since the pace of the course is determined by the intellectual ability of the students, it also improves the success chances of students.

* 1. **Scope and limitations of study**

The system would be limited with implementing adaptivity on a single course, CSC427 (Computer Networking) and would be used by 400 level students of the Department of Computer Science. This is to ensure capturing and analysis of usability results.

* 1. **Definition of Terms**

**Education**: The Process or art of imparting knowledge, skill and judgement.

**Adaptive Learning:** At the most basic level, adaptive learning is the notion that computers can improve educational outcomes, Adaptive learning makes content dynamic and interactive, placing the student at the center of his or her individual learning experience.

**Student Model:** The main component of adaptive e-Learning systems is a student model. It is sometimes referred to as a learning model or user model. It contains all student information, for example, their domain knowledge, behavior, learning level, and other information.

**Expert Model:** The expert model stores information about the material which is being taught. This can be as simple as the solutions for the question set but it can also include lessons and tutorials and, in more sophisticated systems, even expert methodologies to illustrate approaches to the questions.

**Concept Map:** Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts.

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**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Intelligent Technology-based Instruction**

The term “intelligent” when applied to instructional machines refers to any behaviour which if performed by a human instructor would be considered as “good teaching” (Elsom-Cook, 1987). The idea to create intelligent instructional machines dates back to the early days of computer emergence and it strengthened with the advent of AI field. From the first attempts to the present time, intelligence has been realized in instructional machines in different degrees and forms.

In early mechanical teaching machines, intelligence was only a matter of splitting a bigger task into smaller sub-tasks and presenting the tasks to the learners in a fixed order until they could complete the whole task. In these early systems, no feedback was provided, or if

provided, it was not intelligently generated and was only a result of what was pre-defined and programmed in the system (Nwana, 1990).

True intelligence in instructional machines appeared much later, as AI came into existences. During the 1970s and 80s, AI researchers made great strides in the domain of intelligent technology-based instruction, and created systems under the title of intelligent tutoring systems (ITSs) with an almost fixed architecture that were intelligent with regard to their subject matter (What they teach), learners (Who they teach), and instructional methodologies (How they teach it) (Self, 1974). Many different ITSs were designed and developed in AI labs during that period, showing outstanding degrees of intelligence; however, very few of them could find a place out of AI labs. One reason for their lack of practicality was that they were severely dominated by AI and computer science fields without enough cooperation with other related fields. Researchers began to realize that intelligent technology-based instruction is a multidisciplinary rather than a single-disciplined field and it requires the insights from psychology and education, as well as AI and computer science.

Adaptive learning systems (ALSs) are a new generation of ITSs and a hot topic in intelligent technology-based instruction which are intended to compensate for the inadequacies of ITSs.

ALSs are usually concept instructors rather than problem solving tutors and are designed to adapt their content and teaching to the learning styles and preferences, as well as knowledge,

of learners. Their architecture is similar to ITSs, with the addition of adaptive hypermedia technologies which enable them to give learners personalized access to World Wide Web information.

**2.2 How to Integrate Learners**

Learner integration can happen at different layers of an intelligent technology-based

instructional machine and with different levels of sophistication. By the term “learner integration” the author of this article means any consideration of the learner by the instructional machine in order to make the content and delivery of information more adapted and adjusted to the needs and preferences of individual learners. The simplest form of learner integration is providing options that enable learners to alter the interface appearance of the system such as the background colour, font colour, font size, presence or not presence of voice; to mention a few. The aim of such adaptations is to make the learning environment more pleasant for individual tastes. At a more sophisticated level, integration or adaptation can occur by giving the learners a choice of the materials which they see as best for their learning goals. This type of integration has been realized in instructional machines in different forms and levels and is currently a main part of ALSs.

Learner integration is also applicable without the learners paying attention and as they interact with the system. In this situation, the system actively and silently monitors the learners as they do a task or solve a problem, and keeps a history of their activities and what they have or have not learned. This history of activities is stored in the Student Model (may have different names in different systems) of these systems and becomes a basis for giving the learners immediate feedback or determining the level of difficulty of the task. This type of learner integration; similarly, has devoted a vast field of research to itself and has been realized in different degrees and forms in different systems.

Yet, an equally or even more important form of learner integration which has been largely ignored until recent years is to provide a model of the learners to adapt the content and content delivery of the system to the needs and learning styles of the learners. Previous

systems had such a learner model or student model, but the information in it mostly included information about what the learners know or do not know, and what they have learnt or have not learnt. This; however, is not enough because a good human tutor, beside such information, knows how to teach different learners while considering their personal differences and learning styles. Also, the previous systems, though giving their learners some levels of freedom in choosing their content, were at the same time very restrictive in this regard and the content, if there was any content at all, was mostly limited to what existed in their Domain Model. Current systems, using the technology of adaptive hypermedia, have given students access to more information available on World Wide Web.

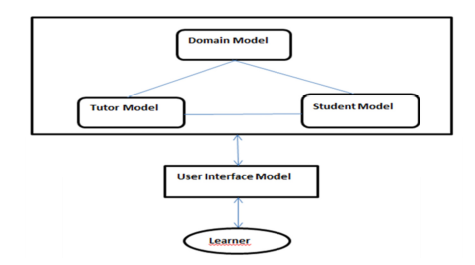
This last type of integration has recently been emphasized in ALSs which are currently the pinnacle of technology-based instruction field. These systems still follow the familiar architecture of ITSs, but their emphasis has shifted from the system itself to the learner. In other words, instead of looking at the learners as passive receivers of information and directed by the system, they attempt to give them more freedom in choice of material and

learning goals based on their individual preferences.

**2.3 Intelligent Tutoring Systems**

ITSs are instructional machines designed based on the principles of AI, education, and psychology fields. These systems perform instructional acts and decisions which if performed by human tutors would be considered as intelligent or good instruction (Elsom-Cook, 1987 & Nwana, 1990). Other definitions include Psotka et al. (1988) who defined ITSs as instructional systems which are designed to give the learner immediate instruction and feedback, almost without any human interference.

ITSs have seen different architectural structures since their emergence and almost every ITS is different from the rest in some details, but a structure which exists more or less in most ITSs is the one consisted of Domain, Student, Tutor, and User Interface models. In short, a domain model is part of ITS which holds information about the subject matter which is taught to the learners; a student model has information about individual leaners and updates itself as leaners interact with the system; a tutor model is the strategic part of an ITS which determines which instructional methods should be used; and finally a user interface model decides the appearance and the type of interaction mode which ITS has with leaners.



**Fig 2.1:** Architecture of Intelligent Tutoring Systems. Adapted from Mathews (1993)

**2.4 Adaptive Hypermedia System**

In adaptive hypermedia systems, the displayed content and offered hyperlinks are chosen on basis on user's specific characteristics, taking their goals, knowledge, and ability into account. Thus, an adaptive hypermedia system aims to reduce the "lost in hyperspace" syndrome by presenting only relevant information. One distinctive feature of an adaptive system is a user model. The user model is a representation of information about an individual user that is essential for an adaptive system to provide the adaptation effect, i.e., to behave differently for different users. For example, when the user searches for relevant information, the system can adaptively select and prioritize the most relevant items (Bruvilovsky & Millian, 2007).

**2.5 Adaptive Educational Hypermedia System**

Education is the largest application area of adaptive hypermedia systems (Brusilovsky, 1998). Most adaptive educational systems only require the user's knowledge of the area of study to function. Adaptive educational hypermedia was developed as one of the possible solutions for the failure of intelligent tutoring systems, the adaptive educational hypermedia solution was to provide a "dynamic" hypermedia textbook in the sense that it changes itself (possibly in an invisible way) to accommodate the reading other chosen by the user (De Bra et al, 2009).

**2.6 Adaptive Learning Systems**

ALSs are a new generation of ITSs which use technology, learning theories, and psychological insights to create instructional systems which adapt their appearance, content, content delivery, and assessment to the knowledge level and personal traits of the learners. Researchers have described ALSs in different ways. According to Sonwalkar (2005), ALSs are systems which are designed to adapt to learners’ preferences and customize learning content according to these preferences. Weibelzahl et al. (2008) define ALSs as tools to individualize the learning process by tailoring the instruction to learners’ preferences, needs, knowledge, and goals. For Chieu (2005), “adaptability is the ability of a learning system to provide each learner with appropriate learning conditions to facilitate his or her own process of knowledge construction and transformation” (p. 70). The common theme to be extracted from the above and similar definitions of ALSs is a consideration of learners which makes a system capable of adjusting its content and instructional methods to the needs, proficiency level, learning styles, goals, and preferences of the learners; similar to what a human tutor does.

ALSs were partly motivated by the more general field of Web-based Education (WBE) that emerged by the spread of internet. Internet revolutionized information by making it accessible to anyone who had any sort of internet access from any kind of device regardless of time and place. This provided a great opportunity for the field of education, since it made information available to many people who did not have the time and resources of attending real classes, being tutored by real instructors, or having access to real instructional materials. Consequently, it led to the emergence and spread of WBE which made this access possible. However, an outstanding shortcoming of pure WBE technologies was their lack of adaptability and intelligence, which made them not efficient enough because such systems are supposed to be used by thousands of learners worldwide, and without some degrees of personalization and adaptiveness, they cannot achieve much success. ALSs emerged to compensate for the shortcomings of the previous systems. Though their hybrid architecture is rather new, they are not totally new in nature and have roots in two more traditional fields, Intelligent Tutoring Systems and Adaptive Hypermedia (Brusilovsky, 1999).

**2.7 Review of Related Projects (Systems)**

**2.7.1 Knewton Adaptive Learning Platform**

Knewton is an adaptive-learning provider company founded in 2008 in New York City. Knewton calls itself the World Leading Adaptive Learning Provider and claims that its adaptive learning platform is capable of adapting content and instructional procedure to the knowledge level, goals, and characteristics of its users. Knewton is an LMS which is already used by a number of outstanding companies, publishers, and educational institutes such as Pearson, Gutenberg, Microsoft, Cambridge University Press, Wiley, Macmillan, etc., which use it in order to boost their user’ learning and performance. Besides, Knewton designers and developers claim that their platform can be used to teach almost any subject, from mathematics to geography and history. Knewton obtains its adaptability power through detecting the users’ performance. It can detect and record different types of users’ actions such as whether they answer a question right or wrong, the amount of time they spend on a task, the learning style which best helps each user to learn a concept, or even the mouse movements when they are hesitating about selecting from a number of options. All these actions are recorded in each user’s profile or student model and are compared with what the user has done before, and how other users have performed in similar situations. The results of such comparisons and analyses are used for adaptation, which occurs in different forms. For example, when a user stumbles with a particular task, the system adapts not only the level of difficulty of the next task, but also the type of it. In other words, if the system detects that a learner has problem with textual tasks, it may present the next task in visual or auditory format ([I1]).

**2.7.2 McGraw-Hill Education ALEKS**

McGraw-Hill Education is a digital learning company located in New York City with

numerous partners around the globe which benefit from its educational content, software, adaptive learning services, and platforms. ALEKS is an adaptive learning platform to teach mathematics, science, and business courses, developed from research at New York University and University of California, and recently released by McGraw-Hill Education. Developers of ALEKS claim that it is unlike any other adaptive learning platform released so far because it is developed by a multi-disciplinary team of computer scientists, mathematicians, and cognitive psychologists, and at its heart lays an artificial intelligence engine.

ALEKS power comes from its ability to use AI to analyze the knowledge state of each learner in order to determine what she already does or does not know. To start with ALEKS, each learner takes part in an assessment test consisting of 20-30 questions. The test is not fixed, rather adapted to each learner; that is, each question in the test depends on how the student responds to the previous questions. ALEKS avoids multiple choice questions and after the initial assessment, it is capable of exactly determining the knowledge level of the learner with regard to any particular course in focus. After the initial assessments, ALEKS constantly observes the learners as they interact with the system and uses its data to present the learners only with the tasks which they are ready for. Also, it assesses the learners periodically to ensure that the learnt concepts can be retained ([I2]).

**2.7.3 DreamBox Learning**

DreamBox Learning is an adaptive learning platform to teach mathematics to elementary students, founded in 2006 in Washington. It uses animations and games to teach mathematics and is based on the principle of “learning by doing”. Students working with DreamBox go through missions, challenges, awards, and punishments to acquire mathematical concepts, and the system keeps them engaged and interested while learning. DreamBox Learning claims to be adaptive and intelligent and is equipped with millions of learning pathways to personalize learning for each learner. DreamBox Learning is based on three principles of rigorous elementary mathematics, motivation learning environment, and intelligent adaptive learning. Based on the first principles, DreamBox Learning attempts to keep the quality and difficulty level of its math content in line with national and international standards. The second principle provokes DreamBox Learning platform to create a learning environment which is engaging and motivating, as well as informative and instructive. The system has achieved this goal through a game-like environment where the learners learn while playing and having fun. The third principle is where the system intelligence and adaptiveness comes from. Students are constantly assessed while working with the system and the results of these assessments are used to adapt the level of difficulty and the pace of instruction to each learner. DreamBox Learning has millions of learning paths, and at each stage, the learners are guided to one of these paths based on the system assessment of them and based on their unique needs. The system is also cautious that each student is moving under the proximal zone of development, introducing at each stage only those tasks for which the learner is ready ([I3]).

DreamBox Learning has been successful so far and most of the reviews about it reflect the positive attitudes of the users. One flaw which; however, some have mentioned is that it cannot be used as the only source of instruction because it does not provide additional alternatives for the users if they cannot grasp a concept. They believe that DreamBox is a marvellous tool if it is used in a blended learning environment where the learners have access to other knowledgeable bodies when they encounter problems.

**2.7.4 ELM-ART** (Brusilovsky & Weber, 2001)

ELM-ART, an intelligent interactive educational system to support learning programming in LISP. ELM-ART provides all learning material online in the form of an adaptive interactive textbook. Using a combination of an overlay model and an episodic student model, ELM-ART provides adaptive navigation support, course sequencing, individualized diagnosis of student solutions, and example-based problem-solving support. A major disadvantage of ELM-ART is that it is built to teach only LISP programming there's no flexibility to creating other courses for the system to teach.

**2.7.5 AEHS-LS** (Mustapha & Sharif, 2011)

AEHS-LS is a system that integrates learning styles into adaptive e-Learning hypermedia. The main objective was to develop an adaptive e-Learning system and assess the effect of adapting educational materials individualized to the student's learning style. The main disadvantage of this project is that it's only models students based on their learning styles.

**2.7.6 ISIS-TUTOR**

ISIS-Tutor is an intelligent learning environment to support learning a print formatting language of an information retrieval system CDS/ISIS/M (ISIS for short). This system was distributed by UNESCO and used widely in Russia and in many information centers worldwide. The print formatting language is a kind of programming language with over 50 different commands and modifiers. It is used to display or print the result of a search, or the content of a database. A complete description of ISIS-Tutor can be found in (Brusilovsky & Pesin, 1994), (Brusilovsky & Pesin, 1994)

**2.7.7 Smart Sparrow**

Smart Sparrow is an adaptive intelligent educational platform founded by a group of intelligent tutoring systems and educational data mining researchers at the University of New South Wales in Australia, to teach medicine and science courses. Smart Sparrow is designed to provide adaptive and interactive learning experiences for its users by giving them adaptive feedback, adaptive pathways, and the possibility for instructors to adapt their teaching. In the first level of adaptiveness, the system offers the students intelligent and immediate feedback as they face a problem in doing a task. The second level of adaptiveness caters for individual learners’ differences. It can detect each learner current level of knowledge, misconceptions, and learning rate, and adapt the level of difficulty and the delivery of the material to them. In the third level of adaptiveness, the system takes the teachers and instructors into consideration. Smart Sparrow is equipped with powerful authoring tools and facilities which enable the teachers to add their content, feedback, videos, simulations, etc., into the system to provide more individualized and interactive learning environments for their students ([I4]).

Smart Sparrow is currently being used in many of educational institutes in Australia, with the perspective of reaching the global markets, and has attracted good attention and investment. However, in comparison to some other adaptive learning systems, this system is not that sophisticated in adapting itself to learners’ differences as it is to help the instructors create interactive courses. Its adaptiveness power lays mostly in its ability to give immediate feedback; and as the system founder has mentioned, the platform is no more than a rule-based system and void of true intelligence.

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