ADAPTIVE LEARNING FRAMEWORK

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By

MUBARAKA SANI IBRAHIM

Supervised by

Professor Mohamed Hamada

African University of Science and Technology
www.aust.edu.ng
P.M.B 681, Garki, Abuja F.C.T
Nigeria

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Declaration of Authorship

I, Mubaraka Sani Ibrahim, declare that this thesis titled,

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ABSTRACT

Many Institutions offer on-line courses to people from all around the world. Learning Management Systems provides a convenient learning environment for on-line courses. Each learner has individual needs and characteristics such as, personality and learning styles. These investigations are supported by learning theorists who argue that, these differences affect individuals learning process, and that is why learners progress better under certain circumstances. Learning style is the outlined method used to place learners in certain criteria based on the way they process and perceive information. Felder-Silverman's learning style model is the implemented model because it combines major learning style models like, Kolb's, Pask, as well as the Myers-Briggs Type Indicator.

In this thesis the adaptive learning framework is created using a Java Spark web framework. MySQL database is used to store data and Java Database Connectivity is used to interface Java with MySQL. Static and automatic student modelling are implemented. Learners learning styles are inferred and the framework suggests, learning materials for learners that corresponds to their learning preferences.

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CHAPTER 1

Introduction

This chapter gives general introduction to the Learning Management System (LMS), Motivation and Problem statement. Research aim, goals and direction are also presented. Later on, the structure of the thesis is described.

1.1 Adaptive Learning Systems & Adaptive Learning Framework

An Adaptive learning system is a platform for teaching, learning,managing courses, and storing user data. In addition, it applies users data to adapt various visible aspects of the system for the user. Adaptive learning systems tailor learners experience to suit individual needs.

Adaptive learning frameworks provide an environment where adaptation and personalization are achieved in order to improve the learning process. Basically, the adaptive learning framework extends the benefits derived from traditional Learning Management Systems (LMS), and incorporates the idea of offering learners personalized support in a distance learning setting.

1.1.1 Learning management system

The Learning management system (LMS) is a platform for teaching, learning and managing on-line courses. The core objective of a LMS is to improve usability and learning. Many institutions make use of learning management systems to offer on-line courses, thereby allowing people to enroll in courses irrespective of physical barriers. Common examples of LMS are Moodle [Moo13], OpenOlat [Ope11] and Blackboard [Bla13]. Although LMS's provide immense support for teachers, they however are limited in addressing learning differences in individuals. An important factor to consider is to, extend the benefits derived from traditional LMS's and incorporate the idea of offering learners personalized support in a distance learning setting.

1.2 Motivation & Problem Statement

The innovation of the internet led to advances in communication and technology. Many educational institutions offer online-courses. E-learning has gained massive popularity because learners from all around the world can participate irrespective of their physical distance. Although LMS's provide a convenient learning environment, LMS's do not address individual differences in learning. An important issue arises here as highlighted by Jonassen [JG93], individuals differ in their ability to process information, construct meaning from it, or apply it to new situations.

The motivation behind this work is to improve learners learning process by, outlining individual differences in terms of learning style, or preferences, and matching these with suitable learning material.

The major drawback of learning management systems lies in its inability to personalize to the system for learners [GL05]. Jonassen further stated that, it is possible to adapt instructions in order to accommodate differences in ability, style, or preferences among individuals to improve the learning outcome.

Therefore a conclusion can be drawn that, adaptive learning systems address exactly this issue, matching learning contents with learner's learning preferences.

1.3 Aims, Goals & Direction of Research

The aim of the project is to investigate methods of detecting learning styles and provide learning material. This will involve, investigating the behavior of students while using the system, and creating software programs that will implement their learning styles. Using these programs, data is stored in student models, and analysis will be carried out on these data. In summary the project aims are given below:

1. To understand and investigate the behavior of users in the system, infer student's learning style and the method used in detecting the learning style.
2. To write a program using suitable programming software that will provide a suitable learning environment and infer student's learning style, and suggest learning material.
3. To discuss implementation of the framework.

In order to realize the goal of this thesis, investigations regarding the following research questions have been conducted:

1. How can learning styles be identified?

In order to personalize the LMS, students learning styles need to be identified. Learning style models are used as a basis for classifying learners based on learning styles. Various learning styles models are discussed subsequently.

2. How can learning material be determined?

Based on the inferred learning style, learning materials are proposed that suit each learning style. According to learning theorists, addressing individual differences in terms of learning, improves learning progress.

In Figure 1.1, the learner accesses the ILS questionnaire from his/her computer or smart device (such as a smart phone or tablet) through the predictive model. The predictive model uses feedback from students to generate learning styles. During the learning

process, the current student data is passed to the predictive model that can help to build the learners profile. The predictive model sends the learning styles to the dashboard and the adaptive engine. The adaptive engine suggests learning contents to learners. Teachers and administrators can monitor the learners' performance through the dashboard and can provide timely feedback to the learners through the intervention engine. Figure 1.1 displays the adaptive learning framework with the following components; adaptive engine, intervention engine, dashboard and predictive model. In addition to students information, the system also contains all the students data.

The role of every component is simply described as follows:

Predictive model: to evaluate students learning styles and learner profiles.

Adaptive engine: suggests learning contents based on generated learning styles.

Dashboard: allows teachers and administrators to monitor the students learning styles.

Intervention engine: allows instructors to send appropriate feedback to the learner based on their observation of the learner's information on the Dashboard.
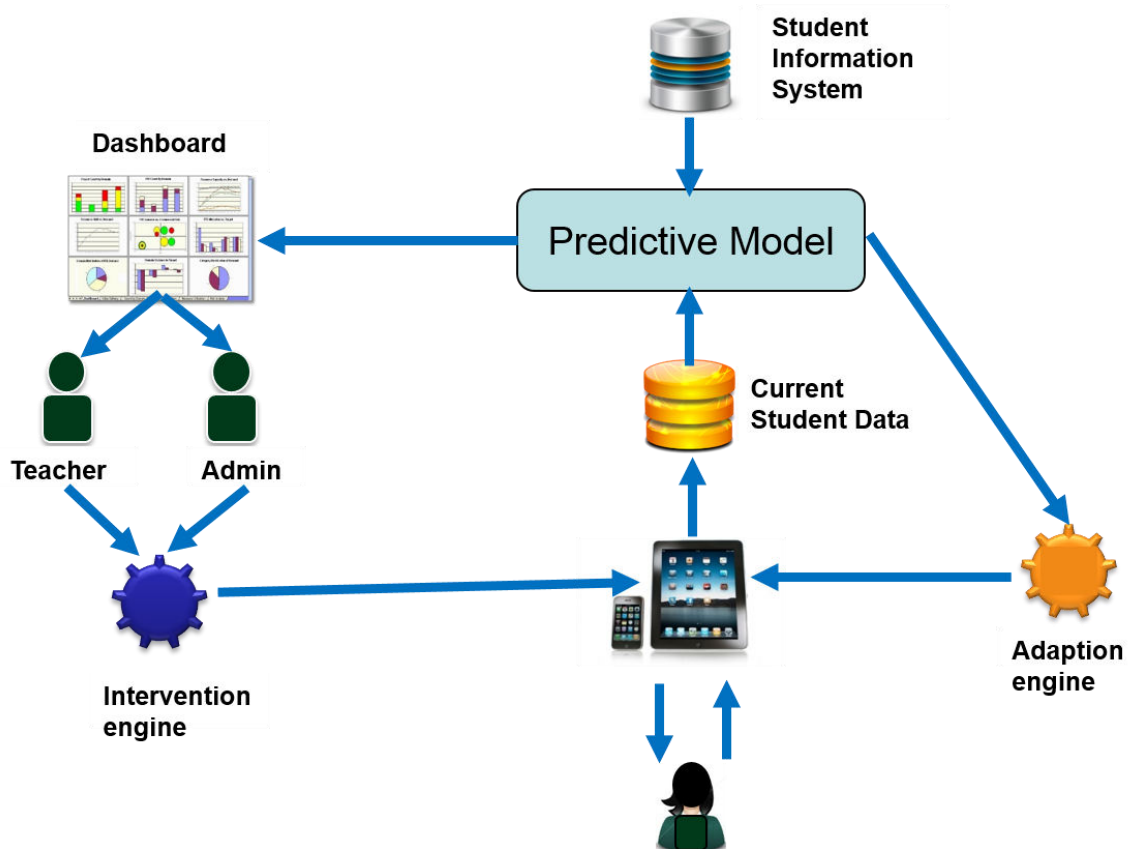
Figure 1.1: Adaptive Learning Framework.

1.4 Thesis Structure

This thesis is outlined in 5 chapters.

Chapter 1 introduces the Adaptive learning framework, learning management system, motivation and problem statement are discussed, and research aims, goals and directions are also outlined.

Chapter 2 deals with Literature Review. Common learning style models are described, and examples of adaptive educational systems are discussed.

Chapter 3 defines the tools used in developing the adaptive learning framework, student's navigational behavior considering learning styles, and methods of detecting learning styles. Proposed framework and working scenarios of Adaptive learning framework are explained.

Chapter 4 Implementation and features of the system are discussed in detail.

Chapter 5 concludes the thesis by discussing major contributions and limitations. Future work is also highlighted.

CHAPTER 2

Literature Review

2.1 Learning Management Systems

Internet invention allows people from all over the world to communicate, such innovation has encouraged the development of new technology. Many institutions like universities make use of learning management systems to offer on-line courses, thereby allowing people to enroll in courses irrespective of physical barriers.

According to Prabhani [MPPL13], two main issues deal with the implementation of an e-learning system. The first is the software platform needed for e-learning, and the second is the learning content prepared to suit the platform.

One example of an e-learning software platform is the Learning management system (LMS).

The Learning management system allows for administration, organising, management and delivery of e-learning courses. There are many open-source learning management systems. Moodle [Moo13] and Blackboard [Bla13] are some of the most commonly used LMS's.

One of the drawbacks of such LMS is its inability to personalise learning content. There are many definitions of learning style in literature. For example:

- Keefe [Kee76] explained learning style as signed indicators that show how the students perceive, interact and respond to learning environments.
- Gregorc [Gre76] states that, learning style is composed of distinct behaviors that show how a student learns from an environment and adopts to himself the knowledge thereof.
- Dunn [DD93], defined learning style as how each student uses distinct and personalized unique ways, to learn and memorize new knowledge.

The next subsection discusses commonly used terms in adaptive education systems.

Then subsequently, learning style models and adaptive education systems are introduced.

2.1.1 Common Terms & Definitions Regarding Adaptive Educational Systems

Graf [GLK05] clearly states the meaning of Adaptability, Adaptivity and Personalisation.

Adaptability: Adaptability includes all the facilities needed to customize the platform for an educational institutions needs (e.g. the language or the design).

Adaptivity: Adaptivity includes all kinds of automatic adaptation of learning material to

the individual users needs (e.g. personal annotations of learning objects or automatically adapted content).

Personalisation: Personalization allows each learner, facilities to customize his/her own view of the platform.

2.1.2 Student Modelling

Student modelling refers to all relevant information about learner's regarding adaptivity.

Graf [Gra07] in her Ph.D thesis describes student modelling as, either static or dynamic. Static student modelling refers to an approach where the student model collects data only once (mostly when the students first access the system).

In contrast, a dynamic student modelling approach frequently updates the information in the student model. They just have to use the system for learning in order to, provide the relevant information about their behavior. It is important to determine a student modelling approach because information from a student model is used to provide adaptivity.

2.2 Student Modelling & Adaptation In Educational System

In order for a system to be adaptive, the system should have a student model to be able to adapt learning material using this model.

Figure 2.1 shows 3 stages of the adaptation process:

1. System collects data about the user.
2. Data usage to build and update a student model.

Applying the student model to provide adaptivity.Information required to build a student model can be acquired through, the user interacting with the the system, or through information provided directly from the user. Users provide data for student modelling, the data provided is processed by the system to build and update the student model.

2.3 Static Student Modelling & Automatic Student Modelling

In static student modelling, users are allowed to provide information for the model explicitly. In this approach, a student model is built and updated with information directly from the user.

In automatic student modelling, information about the user is gathered by tracking the user's behavior pattern while using a system. The student model can be updated based on preferred learning content, time spent on learning contents, and answers generated from questions or tests.
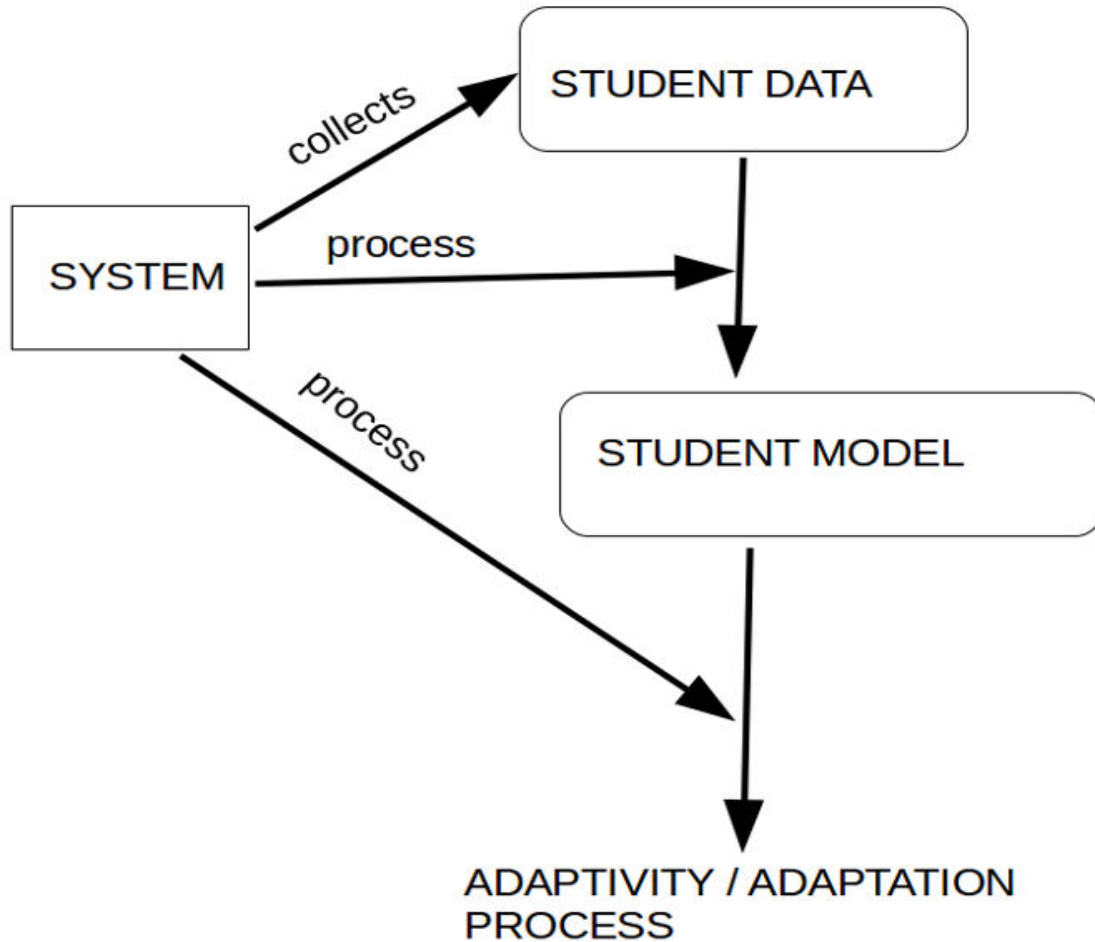
Figure 2.1: Student modelling in Adaptive Educational Systems.

2.4 Common Learning Style Models

The goal of learning style models is to classify students based on their preferred learning style. Discussed below are 4 commonly used learning style models.

The Mayer-Briggs Type Indicator(MBTI)

MBTI [Mye62] describes individuals based on their personality make up. MBTI is a self report questionnaire designed to classify individuals based on characteristic differences such as behavior, thinking and emotion. Four dichotomous dimensions classify individuals either as, extroverted (E) or introverted (I), sensing (S) or intuitive (N), thinking (T) or feeling (F), and judging (J) or perceiving (P). There are 16 combinations of such personality types.

The extroverted-introverted dimension deals with the orientation of a person. Extroverts draw their energy from the physical and social environment such as people and things, whereas introverts concentrate on their inner feelings and prefer to think on their own.

The sensing-intuitive dimension focuses on the way a person perceives information. Sensors perceives data using senses such as sight, hearing, smell or taste, while the intuitive rely on their inner gut and intuition.

The thinking-feeling dimension focuses on the way a person likes to make decisions. In thinking, there is use of logic and facts to draw conclusions, while feeling takes into consideration other people involved and personal concerns.

The fourth dimension is judging-perceiving. Judging people prefer structured and decided lifestyles, whereas the perceiving persons prefer a flexible lifestyle and tend to go with the flow.

Kolbs Learning Style Model

David Kolbs [KK05] Learning Style Model was published in 1984. The model gave rise to related terms such as Kolb's experiential learning theory(ELT), and Kolb's learning styles inventory(LSI). Kolb's learning theory sets out four distinct learning styles (or preferences), which are based on a four-stage learning cycle.

According to Kolb's, this theory represents a spiral where, immediate or concrete experiences lead to observations and reflections. These reflections are then absorbed and translated into abstract concepts with implications for action. The individual can then actively test and experiment with them, which in turn enables the creation of new experiences.

Kolb's model four-stage cycles are:

1. Concrete Experience - (CE)
2. Reflective Observation - (RO)
3. Abstract Conceptualization - (AC)
4. Active Experimentation - (AE)

Based on these cycles, Kolb's identified four learning styles.

- Divergers (CE/RO) tend to look at things from different perspectives. They prefer to observe different situations, and gather information to make conclusions. They are sensitive, imaginative and generally interested in people.
- Assimulators (AC/RO) are more interested in ideas and concepts rather than people.They excel at understanding and organising a wide range of information. These people prefer abstract concepts and sound theories.
- Converging (AC/AE) People with a Converging learning style are more attracted to technical tasks and problems, than social or interpersonal issues. People with a Converging learning style are best at finding practical uses for ideas and theories. They can solve problems and make decisions by finding solutions to questions and problems.
- Accomodating (CE/AE) learning style act on gut instinct rather than logical analysis. They rely on other people's observation and analysis

Honey and Munford Learning Style Model

Honey and Munford learning style model [HM92] invented in 1982, is based on Kolbs experimental theory, Kolb (1984). Four types of learning styles were identified based on Kolb's learning styles Activist, Theorist, Pragmatist and Reflector.

- Activists tend to experiment and try out new things. They are open minded and learn easily by involving themselves in activities with other people.
- Theorists are people that prefer concepts and facts. They like to analyse and synthesize. They are keen on basic assumptions, principles, theories, models and systems thinking. Their philosophy prizes rationality and logic.
- Pragmatists are keen on trying out ideas, theories and techniques to see if they work in practice. They positively search out new ideas and take the first opportunity to experiment with applications. They tend to be impatient with ruminating and open-ended discussions. They like making practical decisions and solving problems.
- Reflectors like to stand back, to ponder on experiences and observe them from different perspectives. They collect data, both first hand and from others, and prefer to think about it thoroughly before coming to a conclusion. The thorough collection and analysis of data about experiences and events, is what counts so they tend to postpone reaching definitive conclusions for as long as possible.

Felder Silverman Learning Style Model (FSLSM)

Felder Silverman Learning Style Model [FS88], classifies learners based on four dimensions. The four dimensions are Active/Reflexive, Sensing/Intuitive, Visual/Verbal, Global /Sequential. Learners are classified according to certain preferences.

- Active/Reflexive: In this dimension learners are classified based on how they prefer to process information. Active learners are interested in communicating with others and prefer to learn by engaging in discussions with other people.
  Active learners tend to be experimentalist, while Reflexive learners prefer to work alone or in small groups. They prefer situations that allow them to think and reflect on learning information. They are also seen as theoreticians.
- Sensing/Intuitive: In this dimension learner preferences are determined by the way they perceive information through their senses. This is either by, collecting facts or through the unconcious use of one's gut or imagination. Sensing learners prefer facts and experimentation. They are comfortable with the standard way of doing things.
- Visual/Verbal: This dimension is based on the way people receive information. Visual learners learn best when presented with physical learning material like graphs, pictures and diagrams, while verbal learners prefer to hear and discuss with others what they hear.
- Global/Sequential: Sequential learners progress in a linear manner towards learning, while global learners learn in leaps. Global learners prefer overview while global learners are interested in sequential learning.

2.4.1 Examples of Adaptive Educational Systems

In this section, adaptive learning systems that provide adaptivity according to learning styles are introduced. The adaptive systems discussed are based on learning style models they implement, and adaptive features used to identify the learning styles.

2.4.1.1 CS383

CS383 [CHL99] is the first adaptive system that incorporates Felder-Silverman's learning style model (FSLSM). CS383 implements sensing/intuitive, visual/verbal, and sequential/global dimensions of FSLSM. The system forces students to constantly make choices. This facilitates active learners who become actively involved in the learning process. Reflective learners are likewise, facilitated by the computer-based nature of the material.

Students can stop and reflect at any point during their studies, and ponder the meaning of the material presented. Therefore active/reflective is removed from consideration leaving, sensing/intuitive, visual/verbal, and sequential/global dimensions. Adaptivity is provided

by presenting lesson media elements like graphics, digital movies, hypertext and sound files to each student in a sorted list. Students learning styles are then determined by answering a series of twenty-eight questions. When a student logs in to begin a lesson, the student is given the option of exploring the course material according to their learning style or without their learning style.

2.4.1.2 IDEAL

Intelligent agent assisted environment for active learning (IDEAL) [SSC01]. IDEAL is an intelligent agent assisted system that, incorporates active learning by supporting highly interactive learning. In this system, learning styles and background knowledge are used for selecting and organizing learning material for individual students. IDEAL is implemented using the prevalent Internet, Web, digital library, and multi-agent technologies.

Student modelling is used to adapt to the needs and knowledge of individual students.

In IDEAL, a student model is inferred from the performance data using a Bayesian belief network. The system also incorporates a new approach to course content organization and delivery by, developing smart instructional components which are integrated into a wide range of courses.

2.4.1.3 MASPLANG

MASPLANG [Pen04] is a multi-agent introduced to bring adaptive characteristics to the USD e-learning environment (a Course Management System). For student modelling, the learning style is determined by applying FSLSM Index of learning style questionnaire.

The student modelling in MASPLANG involves two elements: the student model, which allows the different features of the students (i.e. knowledge, preferences etc.) to be considered in the learning process and the User agent, which is the student manager that identifies the student objectives, and updates the student model. Through the student's interaction with the system, the student's knowledge and learning style are determined.

According to a student's action, the system provides adaptation by selecting content according to the student's learning style.

Student assistance is built using Information and Assistance agents. The assistant agents provide assistance to students by, registering student actions to identify patterns for personalizing the presentation of the learning content and, the navigation tool for students. The information agents make the student feel comfortable when he/she carries out the learning activities, an animated, life-like character (the SMIT agent) has been designed to display the reinforcement information and the programmed alert messages .

There are two Information agents. The first is the User agent designed to maintain the

student model, and the second is the Pedagogic agent which evaluates the pedagogic decision rules that are embedded in the pedagogic model of the course.

2.4.1.4 LSAS

The Learning Style Adaptive System(LSAS) [BF] is a system that incorporates global and sequential learning styles. The Felder-Solomon Learning Style Questionnaire was used to measure the learning style preferences of students. To provide adaptivity, two different presentation-style-user-interface templates were employed. The system provides an alternative to the, one size fits all approach to development of web-based educational course ware, by creating learning materials to cater for individual learner preferences. For students with a global learning style preference, pages comprised elements such as a table of contents, summary, diagrams, overview of information etc. For sequential students, the pages contained small chunks of information, text-only pages with forward and back buttons.

2.4.1.5 INSPIRE

An Intelligent System for Personalized Instruction in a Remote Environment [GPKM] incorporates the idea of offering learners personalized support and/or instruction in a distance learning setting. Based on the learning goal that the learner selects, the system generates lesson plans tailored to the needs, preferences and knowledge level of each individual learner by making use of information about the learner gathered through their interaction. Honey and Munford's learning style model [HM92] (Activists, Pragmatists, Reflectors, Theorists) is used to determine a learner's learning style.

In INSPIRE, learners with different learning styles view different presentations of the educational material. The main objective is to support learnersby following their preferred way of studying. Thus, all learners are provided with the same knowledge modules. However, the method and order of the different representations that they include is adapted. For example Reflectors tend to collect and analyze data before taking action, therefore example-oriented contents are proposed, allowing analysis of data before taking action. Activists are more inclined towards experimentation and challenge, therefore activities designed for example computer simulation are proposed, thus providing them with the necessary information (examples and theory).

2.4.1.6 TANGOW

TANGOW [CPR01] stands for Task-based Adaptive learner Guidance. On the world wide web, TANGOW incorporates two dimensions of FSLSM, namely the sensing/intuitive and the sequential/global dimensions. Adaptation is realized by modifying the order of tasks and the order of elements within the tasks. Course designers can build the default

order of tasks using, AND, ANY,OR, and XOR rules. For a sequential learning style, all ANY rules were replaced by AND rules in order to, provide a more structured path through the learning material. In contrast,for a global learning style, all AND rules were changed to ANY rules. Regarding the sensing and intuitive learning style dimension, the order within the tasks is modified. For sensing learners, the example is presented first, followed by the explanation. On the other hand, for intuitive learners, the explanation is shown first, followed by the example.

2.4.1.7 AHA!

AHA! (Adaptive Hypermedia Architecture) [BAB 01], is an open source general-purpose adaptive hypermedia system (AHS) for e-Learning. AHA! does not provide any questionnaire to identify the learning styles. Instead, a registration form is provided where the incorporated learning styles are described and students can manually state their learning style preferences. Adaptation in AHA! is based on a number of attributes associated with concepts. AHA! performs adaptation by, adaptive link hiding or link annotation. When a page is generated, links marked as conditional(using the link class conditional) are displayed differently depending on the suitability of the link destination. If the expression is true, the link is shown in blue (unvisited) or purple (visited), and when the expression is false, the link is shown in black, and not underlined. This results in hiding the unsuitable or undesired links. Content adaptation in AHA! uses the conditional inclusion of fragments technique. There are two ways to use this technique in AHA!, with embedded fragments or with objects. Embedded fragments appear within a page, and are included if an associated suitability expression evaluates to true.

AHA! incorporates author tools such as Concept Editor, Graph Author, Form Editor and Test Editor among many others. Courses are presented as contents in html and xhtml. It also provides a layout model to determine the desired look and feel of a course.

TABLE 2.1: Summary Of Adaptive Educational Systems.

System	Year	Learning Style Model	Adaptation based on Learning Style
CS383	Carver et al., 1999	Sensing/intuitive, visual / verbal, and sequential/-global (Felder and Silverman, 1988)	Lesson media elements are presented in sorted manner to each learner according to his or her learning style.
AHA!	(Bra et al., 2000)	Determined by students.	Adaptation is provided by adaptive link hiding or link annotation.
INSPIRE	Grigoriadou et al., 2001	Honey and Munford learning style model(1986,1992)	Adaptation provided by providing all learner's with the same knowledge modules. However, the method and order of the presentation of the different representations that they include is adapted.
IDEAL	Shang et al. 2001	Determined by the teacher	Course content organization and delivery by smart instructional components which are integrated into a wide range of courses.
TANGOW	(Caro et al., 2001)	The sensing/intuitive and the sequential/global dimensions(FSLSM)	Adaptation is realised by modifying the order of tasks and the order of elements within the tasks.
LSAS	(Bajraktarevic et al., 2003)	Sequential/global dimension of FSLSM	Adaptivity is provided by two different presentation style user interface templates.
MASPLANG	(Pea, 2004)	FSLSM	Adaptation is provided by selecting content according to the student's learning style.

CHAPTER 3

Adaptive Learning Framework

In this chapter a summary of tools used is given. The incorporated learning style model is discussed. Analysis of learner's behavior in adaptive learning management system is done.

Finally two main methods of detecting learning styles; static and automatic learning style detection are discussed.

3.1 TOOLS

A brief summary of tools used in this thesis is given below:

1. Front End: Twitter bootstrap CSS [Boo] and HTML components to design the user interface. This allows the development of a responsive web site that will cater for both mobile and desktop viewing.
2. Java Spark web framework [Spa] is used to handle web requests and URLs. Routes are invoked whenever a request that matches the route is made. Three basic parameters, request, response and redirect are used to, provide web request, response information and redirect browsers respectively.
3. Database: MySQL database is used to store data. JDBC adapter in JAVA is used to inter-face with MySQL. Details of the database are given in the following section.

3.1.1 Database

MySQL database is used to create the following tables:

- LECTURER TABLE: This is used to store lecturer information such as first name, email and password. The role of the lecturer is to create courses, observe student discussions in the forum and recommend learning material based on inferred learning style.
- STUDENT TABLE: This is used to store student information, such as first name, email and password. The role of the students is to answer the provided questionnaire, access course material, and participate in discussion forums.
- ADMIN TABLE: This is used to store store information, such as first name, email and password.
- COURSE TABLE: This table is used to store information about courses such as course name and course title.
- CONTENT TYPE TABLE: This table is used to store meta data about different content types such as exercise, example, self-assessment test, outline, content, forum. This table allows lecturers to select content type when adding course contents.

- COURSE CONTENT TABLE: This table is used to store information about course contents.
- FORUM TABLE: This table is used to store information about discussion forums.e.g comments.
- LEARNING STYLE TABLE: This table is used to store information about learning styles such as the learning style dimension of students.
- METRIC TABLE: This table is used to store information about the number of visits and time spent on content types such as exercise and examples.
- Questionnaire TABLE: This table is used to store information about students with regard to Felder Index Of Learning Style Questionnaire.

The image of the physical model of the database, showing tables with relationship(s) between them generated using MySQL workbench is included in Appendix one.

3.2 Felder-Silverman Learning Style Model (FSLSM)

FSLSM [FS88] is the selected learning style model for this thesis. This model classifies the students based on active/reflective, sensing/intuitive, visual/verbal, sequential/ global dimensions. As mentioned in section 2.4, students learning styles are determined and based on four dimensions. The Index Of Learning Style Questionnaire [FS97], is used to place learners in four dimensions based on certain characteristics. The strength of each dimension is measured on a scale of 1-11. For example if a student has a score 1-3 for a dimension, he/she has a weak preference for that learning style. A more detailed description of ILS questionnaire is given below.

Activist/Reflector			Sensing/Intuitive			Visual/Verbal			Sequential/Global		
Q	*a*	*b*	*Q*	*a*	*b*	*Q*	*a*	*b*	*Q*	*a*	*b*
1			2			3			4		
5			6			7			8		
9			10			11			12		
13			14			15			16		
17			18			19			20		
21			22			23			24		
25			26			27			28		
29			30			31			32		
33			34			35			36		
37			38			39			40		
41			42			43			44		
Total (add up each column)											
Activist/Reflector			**Sensing/Intuitive**			**Visual/Verbal**			**Sequential/Global**		
Q	a	b	Q	a	b	Q	a	b	Q	a	b
Larger – Smaller + Letter of Larger (see below*)											

Figure 3.1: Index Of Learning Style Questionnaire adapted from Felder & Solomon [FS97]

3.2.1 Index Of Learning Style Questionnaire

The Index Of Learning Style Questionnaire consisting of 44 questions with, "a" or "b" options is used to determine students learning styles. This questionnaire comes with 11 questions for each dimension. Students are required to fill in the questionnaire the first time they use the system, and the questionnaire will give each learner an idea about his/her learning preference. In this order, question 1, question 2, question 3, question 4 correspond to active/reflective, sensing/intuitive, visual/verbal, sequential/global dimension, in the same way that question 5, question 6, question 7, question 8 correspond to the above learning styles and so on.

3.2.2 Learning Style Questionnaire Evaluation

The students learning style is evaluated based on students feedback. In MySQL database, a table 'Questionnaire' with 44 answer columns is created to store students feedback.

The questionnaire is evaluated as follows:

1. If a student answers "a" for question 1, 1 is stored for question 1 in the questionnaire table, or if a student answers "b", 1 is placed for question 1 in the questionnaire table.
2. Then for each dimension, add up 'like' answers.
3. For each dimension subtract smaller numbers from a larger one and append with the letter of the larger number, for example if a student has a total of 3 for "a" and 8 for "b". 8 - 3 = 5. Since b is larger than you will enter 5b.

The score sheet is shown in Figure 3.1.

Explanation of scores

- A score on a scale of 1-3, indicates a mild learner for one or the other dimension.
- A score on a scale of 5-7, indicates a moderate learner for one or the other dimension of the scale.
- A score on a scale of 9-11, indicates a strong learner for one dimension of the scale. You may learn easily in an environment which supports that preference.

3.3 Behaviour Of Students In A Learning System Considering Learning Styles

In this study, student behavior is analysed by providing students with different course materials. For example a course can be outlined in chapters; each chapter containing materials like outline, content, exercise, example, self-assessment exercise and a discussion forum. The behavior of learners in adaptive LMS is implemented based on Graf et.al [GK08] online behavior to FSLSM mapping.

The 4 dimensions of FSLSM and learners behavior that correspond to each dimension are discussed below:

1. Active / Reflexive Learners

Active learners tend to understand and retain information by engaging in discussions with others. Active learners prefer interactive learning environments.
For example, active learners will benefit from study groups that allow members to take turn explaining topics among themselves. Also active learners prefer an interactive classroom that allows them to get involved in learning activities.

On the other hand, reflexive learners prefer an environment that allows time to think about learning materials in order to comprehend. Reflexive learners prefer to observe their environment and gather information.

In this thesis, a discussion forum is used as an environment to categorise active / reflexive learners. Since active learners understand information by actively interacting with others, the number of forum visits, amount of time spent in a forum and number of posts is considered as the study pattern of active learners. On the other hand the number of forum visits and amount of time spent is considered a study pattern since reflexive learners prefer to observe their environment without necessarily participating in the discussion.

2. Sensing / Intuitive Learners

Sensing learners tend to like learning facts and working with well-established methods. Intuitive learners prefer discovering new learning possibilities, solving problems and often prefer abstraction when compared with sensors.

Intuitive learners tend to be more innovative with ideas for solving problems.

Sensing learners are inferred by their interest in examples compared to intuitive learners. Therefore, the number of example visits and time spent on examples is seen as a pattern. Also since sensing learners are patient and more careful with details, they want to clarify the specifications by asking in forums, and are also interested in the questions and answers of others. Since sensing learners are more interested in details, they tend to visit and spend more time in self-assessment tests. Questions with details are also a pattern.

3. Visual and Verbal Learners

Visual learners tend to like visual information and remember mostly what they see. Visual learners prefer courses that display visual information such as pictures, graphs, diagrams and flowcharts.

Verbal learners understand more spoken words and remember what they hear. Verbal learners tend to learn more in study groups that involve talking and listening to other members.

4. Sequential and Global Learners

Sequential learners understand information in logical steps and they tend to get more by making connections while learning. Sequential learners understand course material that is outlined in linear sequence.

Global learners understand information in leaps rather than in logical steps. Global learners tend to understand information randomly without making connection. Learners with a global preference visited more often the course overview, more than sequential learners. Also, sequential learners are more interested in course content when compared to global learners.

Table 3.1 Summarises online behaviour to FSLSM mapping [GK08] .

Pattern	Active/Reflexive	Sensing/Intuitive	Sequential/Global	Visual/Verbal
outline_visit			✓	
outline_stay			✓	
content_visit	✓	✓		✓
content_stay	✓	✓		
exercise_visit	✓	✓		
exercise_stay	✓			
example_visit		✓		
example_stay	✓	✓		
self_assessment_visit	✓	✓		
self_assessment_stay	✓	✓		
forum_visit	✓			✓
forum_stay	✓			✓
forum_post	✓			✓
navigation_overview_visit				✓
navigation_overview_stay				✓
question_fact		✓		
question_detail		✓	✓	
question_graphic				✓
question_concepts		✓		
question_text				✓
question_overview				✓
question_develop		✓		

While investigating students behavior pattern in the adaptive LMS, navigation overview visit, navigation overview stay, question develop, question fact, question detail, question graphic, question concepts, question text, question overview have not been implemented.

3.3.1 Adaptive Learning Framework Working Scenario

The working scenario of the Adaptive Learning Framework is defined by the users interaction with the system, and the learning content. The instructor prepares a course and sets up different course content to detect adaptivity. The student model is initialized when the student first accesses the system, and the system asks the students to answer the ILS questionnaire. Considering learning contents, information about time spent and number of clicks is stored in the system database. Hence the learners learning profile is created.

Learning styles are inferred based on the student model. LMS displays students learning styles to the lecturer. After answering the Felder questionnaire, the system provides the learner with his/her learning style.

The instructors interaction with the system may be summarized as follows:

The instructor adds a course and sets up learning content. The system provides a facility for selecting course content like outline, content, examples, exercise, and self-assessment exercises. A facility 'feedback' is provided for students input. Discussion forums are also provided for interactive learning. The LMS displays learners learning style to the instructor and/or administrator. The instructor and/or administrator sends feedback to the learner based on his/her observation.

Figure 3.2 shows the work flow of the system and can be summarized as follows:
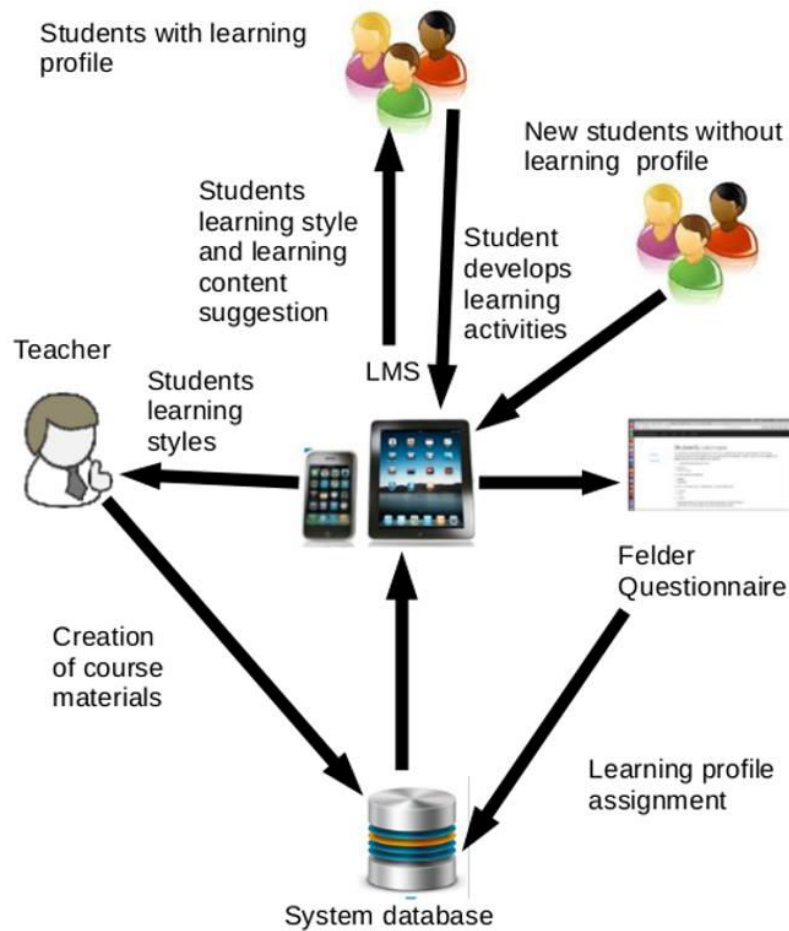
Figure 3.2: Adaptive framework working scenario

1. Adaptive learning framework presents the Felder questionnaire the first time students access the system, which is students without a learner profile.
2. The framework classifies learners based on students feedback concerning the questionnaire.
3. The students develop profiles through learning activities, e.g. visiting the forum.
4. The framework suggests learning content based on student's learning style.
5. The instructor observes students learning styles and provides feedback.

3.4 Static & Automatic Learning Style Detection

In this section methods used to detect learning styles are discussed. In traditional LMS, courses are provided to it's registered users, and instructors are allowed to upload course content. However in adaptive LMS, features that support adaptivity are incorporated in the system. In the implementation, the Felder questionnaire is stored in the database. In addition, the learners information system stores feedback from the users.

However, questionnaires are static and describe the learning style of a student at a specific point in time. This framework supports automatic student modelling approach. A METRIC table stores students activity information in the database. For example, activity information like number of visits and time spent considering course content. In automatic student modelling approach, no effort is required from the students to detect the learning style because, student activity information is stored from learners activities while using the system.

3.5 Features Of Adaptive Learning Framework

In the proposed framework, features that support and detect learning styles are setup. Discussion forums provide mainly two functions; to update students information activity, and to support interactive learning. Most LMS supports the latter. Instructors set up courses and course content. With regards to course content that requires learners feedback, the feedback facility can be activated by the instructor. Generated learning styles are displayed to the learner, instructor and administrator.

The system allows 3 main views: lecturer, administrator and student. A brief summary and screen shots of Adaptive learning systems is given below:

1. Home page: Figure 3.3 displays a home page. Homepage provides access to login page and courses.

Figure 3.3: Home page

2. Login page

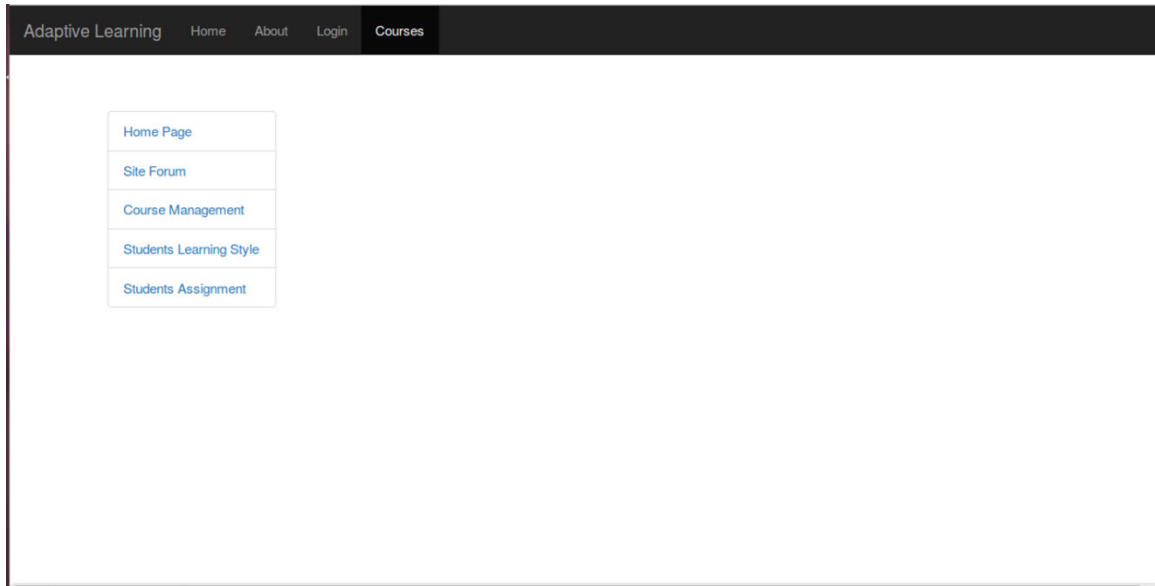Login page that allows Lecturers, Students and Admin to register or log in the LMS is depicted in Figure 3.4.

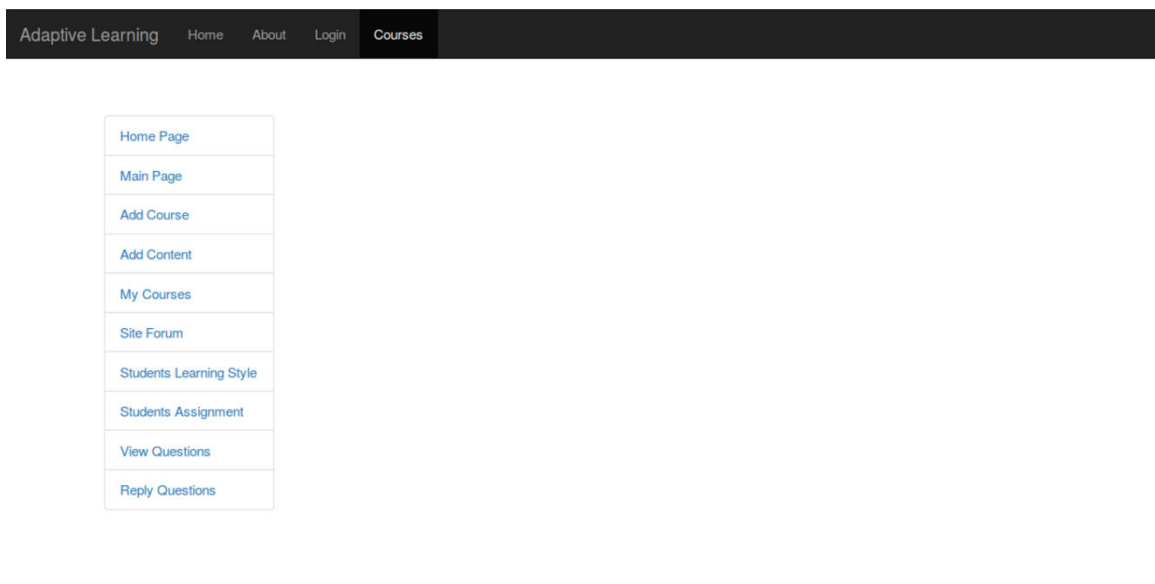**Figure 3.4: Login page**

3. Lecturer main page.

Lecturer main page that allows Lecturers to view Site Forums, view courses and manage courses is depicted in Figure 3.5.

Figure 3.5: Lecturer main page

4. Manage courses page

A page that allows Lecturers to add and/or remove courses and course content is depicted in Figure 3.6.

Figure 3.6: Manage courses page

5. Add courses.

Figure 3.7 displays a page that allows Lecturers to add courses.

Figure 3.7: Add courses page

6. Course list page

Figure 3.8 displays a list of courses.

Figure 3.8: Course list

7. Add course content. Figure 3.9 displays a page that allows Lecturers and Admin to add and/or remove course content.

Figure 3.9 Add course content

8. Students learning style page. Figure 3.10 displays a dashboard of all students learning styles.

Figure 3.10: Dashboard

8. Student questionnaire page. Figure 3.11 displays Students questionnaire.

Figure 3.11: Questionnaire page

9. Main student page.

Figure 3.12 displays a page that allows students to access courses, forum and their learning style.

Figure 3.12: Student's main page

10. Students course list page. Figure 3.13 displays students courses.
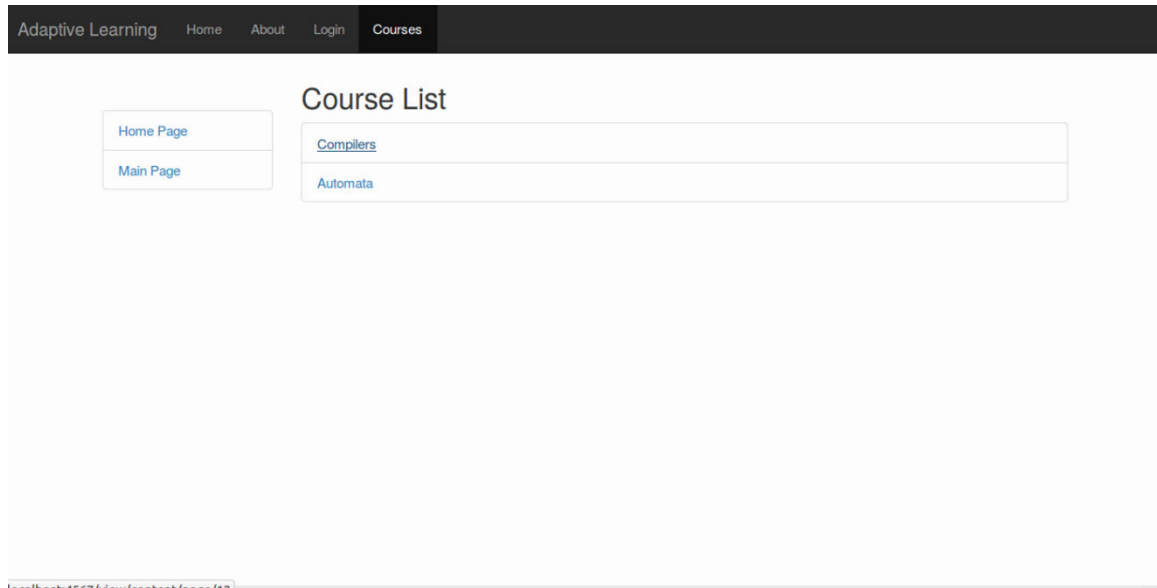
Figure 3.13: Students Course List

11. Students course content.
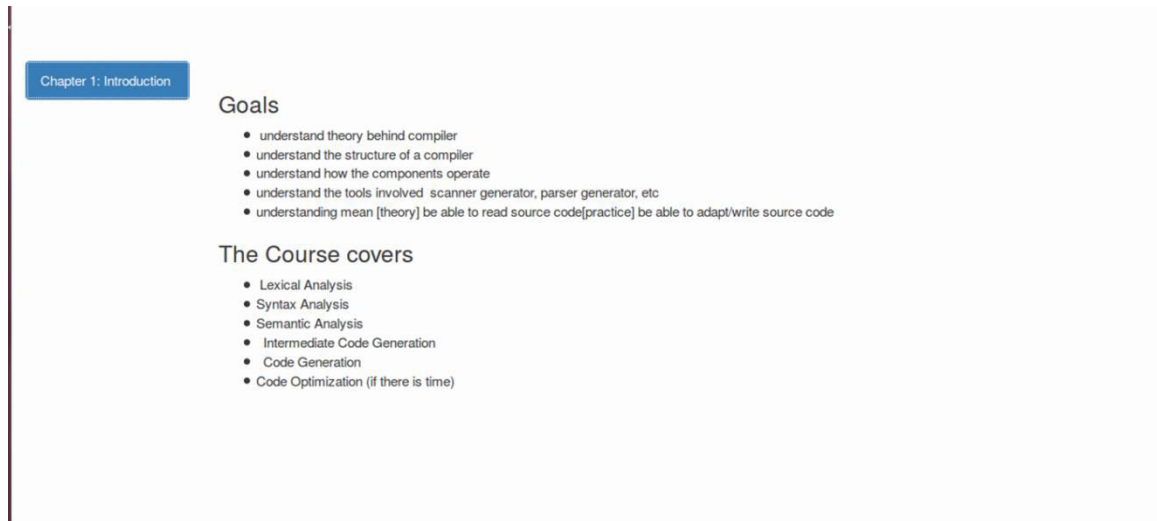
Figure 3.14 displays course content page.

12. Learning style page

Figure 3.15 displays page that allows students to view their learning style.
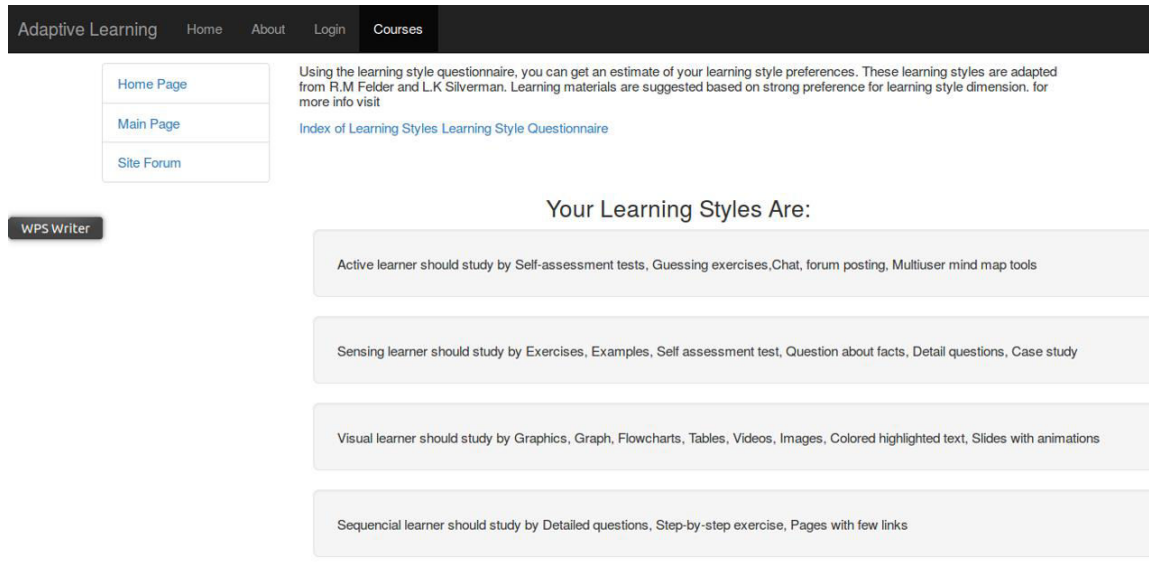
Figure 3.15 displays learner's learning style.

13. Forum Page.

A page that allows interactive learning shown in Figure 3.16.
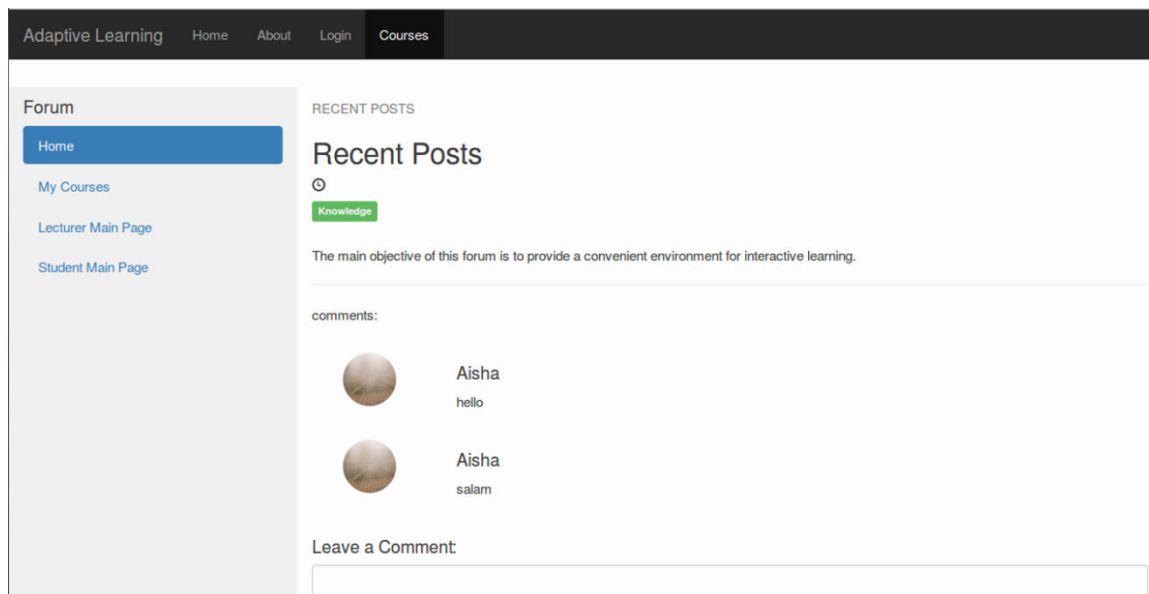
Figure 3.16 displays discussion forum

CHAPTER 4

IMPLEMENTATION

This chapter describes the web interface, Http web server and MySQL database. The different roles of users and accessible features. Functionality of Intervention engine, predictive model, adaptive engine and dashboard.

4.1 Http Server & MySQL Database

In this thesis a new web based LMS was designed and developed to meet the following requirements:

1. Ability to serve both mobile and desktop users.
2. Ability to manage courses and course content.
3. Ability to adapt learning based on studied learner learning styles.
4. Ability to monitor learners learning style.
5. Ability to automatically build learners profile.

The designed LMS consists of three general components.

1. Web Graphical User Interface

Responsive cascading style sheets (CSS) was implemented using the popular Twitter bootstrap CSS library [Boo] to design the user interface. This allows the development of a responsive web site that will cater for both mobile and desktop viewing.

2. HTTP Web Server

The current implementation of the system is using jetty web server running on Linux Ubuntu., This processes the requests made by the learners. Java Spark web framework is used to handle web requests and URLs. Routes are invoked whenever a learner or instructor makes a request that matches the route. Three basic parameters, request, response and redirect. They are used to provide web request, response information and redirect browser respectively.

3. Database

MySQL database is generally used to store learners data. The Java Database Connectivity (JDBC) adapter in JAVA, is used to interface with MySQL database. The most interesting tables in the database are QUESTIONNAIRE, LEARNING STYLE, METRIC and

COURSE CONTENT tables.

Summary of Tables is given below:

1. QUESTIONNAIRE Table: is used to store information about students with regard to Felder & Solomon's Index Of Learning Style Questionnaire [FS97].

2. LEARNING STYLE Table: This table is used to store information about learners learning style dimension.

3. METRIC Table: This table is used to store learners profile concerning, the time spent on each course content and the number of course contents visited by the learner. The METRIC table is implemented based on Graf's [GK08] online behaviour to FSLSM mapping. Table I displays the information stored in the METRIC Table.

4. COURSE CONTENT Table: This table stores meta-data about course content, representing the general characteristics of the different categories of FSLSM.

Summary of Figure 4.1 is given below:

1. When a client sends a request through the web interface to http server.

2. The server processes the request and responds to the client's request.

4.2 Role Of Users.

Adaptive learning framework is separated into areas for learners and instructors.

General features include:

1. All courses page.

2. A Lecturer, Administrator and Student login / registration page.
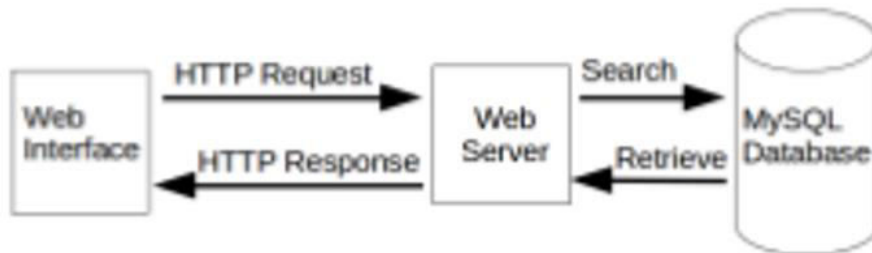
Figure 4.1: Http server and MySQL database

* Instructors

In this framework, users with instructor roles can access the following features:

1. A login/registration page that allows access to the system.

2. Course management system to create and manage courses.

3. Course content management system to create and manage course content.

4. Course content feedback that allows learners to provide input.

5. Instructors learning style page that displays a list of all learners learning style.

6. A forum page that allows instructors to engage in live interaction with the learners.

* Learners

The framework provides a convenient learning platform for learners. Some features in the framework that supports instructors include:

1. A login/registration page that allows access to the system.

2. A course page that allows learners to select courses.

3. A course content page that allows learners to access learning content.

4. A forum page that allows learners to engage in live interaction with the instructors.

5. Learning style page that displays learners learning style and recommended learning content.

4.3 PROPOSED FRAMEWORK

The Adaptive learning framework is proposed to improve individual learning processes and thus, achieve higher learning experiences. The proposed framework is designed to:

1. Allow instructors to set up courses and course content.

2. Consider learner profiles to generate learning styles and provide personalization.

3. Create a personalized list of recommendations to be presented to the learner.

4. Allow teachers and administrators to monitor students learning styles.

Figure 4.2 shows the organization of the components of the system. In this framework, FSLSM is used for classifying and suggesting learning material to individual students.

The framework allows learner's to understand their learning preference. In terms of adaptivity, when recommending course content, students are provided with the opportunity to access all available resources in a course rather than, restricting students to the recommended material. This thereby allows learners to make the better decisions and to strengthen their not preferred learning style.

The 4 main components of an Adaptive learning framework are intervention engine, predictive model, dashboard and adaptive engine. The functionality of these components are described below:

1. Predictive Model

Predictive model initializes the learning style of the learner through the submission of the questionnaire developed by Felder & Solomon [FS97]. The first time a learner logs in, the model presents an ILS questionnaire to them ,and stores the student's learning style in the Learning Style & Course Content Recommendation database. A factor for the determination of the learners profile concerns, the time spent on each course content, and the number of course content visited by the learner for the course. The model then generates a learners profile based on his/her learning activity and stores it in the Learners Activity Information database.

2. Adaptive Engine

Adaptive engine suggests learning content generated based on the learning style. Considering FSLSM, Learning content is recommended based on strong, or balanced preference for each learning style dimension. The main objective is to support learners, to understand their weak and strong learning preferences. The framework allows learners to also train their not so preferred preferences, and allows learners to develop their weak preferences.

3. Dashboard

Dashboard allows teachers and administrators to monitor the students learning styles. Knowledge of learners learning styles allows instructors to, adjust teaching strategies and learning contents, to accommodate learning style.

4. Intervention Engine

Intervention Engine allows the instructor to suggest learning content to learners after monitoring students learning styles from the dashboard.

In this project, Intervention engine has not been implemented.

4.3.1 LEARNERS PROFILE

The implementation of the framework generates learners learning profiles, based on the learners activity information. Learners activity includes, the time spent on each course content and the number of course content visited by the learner for the course. Learners online behaviour patterns are matched with FSLSM. For example, active learners will benefit from study groups that allow members to take turns in explaining topics among themselves, therefore a feature like a discussion forum aids in placing learners in the active/reflexive dimension. Although learning content is integrated for the purpose of detecting learning style, automatic learning style detection has not been implemented.

Table 4.1 displays implemented learner activity information.

Figure 4.2: Adaptive Learning Framework

Learners Activity
exercise_visit
exercise_stay
example_visit
example_stay
self_assessment_visit
self_assessment_stay
outline_visit
outline_stay
content_visit
content_stay
quiz_stay_result
forum_visit
forum_post
forum_stay
forum_read

Table 4.1: METRIC Table

4.4 General Features Of Adaptive Learning Management Systems

In order to conclude that the created framework is adaptive, the framework must support basic functions and features as well as adaptation issues.

Features and functions required for adaptive LMS are given below:

1. Communication Tools: support functional communication tools such as forums, chats and messages.

2. Course Management Functionality: feature for course management aspects.

3. Learning Content Management Facility: features for creating learning objects such as tests, exercises, and examples.

4. Management of User Data Storage and user behavior.

5. Usability Quality: user-friendliness, support, documentation, and assistance in the system.

6. Available features for handling of adaptability, personalization and adaptivity.

Table 4.2 shows features and functions supported by the created Adaptive learning framework.

	Adaptive Learning Framework
Communication	✓
Course management	✓
Learning content management	✓
User data management	✓
Adaptivity	✓

Table 4.2: Adaptive Learning Framework Functions

CHAPTER 5

CONCLUSION

This chapter summarizes the work conducted within this thesis, and the contributions of this work are highlighted. Subsequently, limitations of the research work are described. The thesis concludes with a discussion on future work.

5.1 Summary & Contribution

The aim of the thesis was to create adaptive learning framework that would manage courses and course content. The framework needed to adapt to learning based on learners learning styles. In this thesis, learners were classified based on learning styles. Over 70 learning style models were identified. A learning-style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information.

The Mayer-Briggs Type Indicator (MBTI) described individuals based on their personality make up. MBTI modelled four dimensions, extroversion-introversion, sensing-intuition, thinking-feeling, and judging-perceiving.

David Kolbs Learning Style Model set out four distinct learning styles (or preferences), which are based on a four-stage learning cycle: Concrete-Experience - (CE), Reflective-Observation - (RO), Abstract-Conceptualization - (AC), and Active -Experimentation -(AE). Based on these cycles, Kolb's identified four learning styles" Divergers (CE/RO), Assimulators (AC/RO), Converging (AC/AE), Accomodating (CE/AE)).

Honey and Munford Learning Style Model was based on Kolbs experimental theory. Four types of learning styles were identified based on Kolb's learning styles. Activist, Theorist, Pragmatist and Reflector.

FSLSM was the selected learning style model for this thesis. This model classifies students based on active/reflective, sensing/intuitive, visual/verbal, sequential/ global dimensions. FSLSM was selected because it was the most suitable model for computer based learning. The Index Of Learning Style Questionnaire was used to place learners in four dimensions based on certain characteristics. The strength of each dimension was measured on a scale of 1-11. The adaptive LMS first presented the learner with an ILS questionnaire, and generated learning styles based on the questionnaire. Resultantly, learners are the allowed to access courses and course content.

The framework kept track of learners activities and stored the information on the database, hence the system supported both the static and automatic student modelling approach. Static student modelling was achieved through students performance concerning ILS questionnaire, while automatic student modelling was achieved through learners interaction with learning content. In automatic student modelling, the number of visits and time spent on learning objects was used to generate learner profiles. Further, although

automatic student modelling was implemented, only static learning style detection was achieved. Therefore, the automatic student modelling approach is important because it provided the information needed to implement automatic learning style detection.

Once learning styles were known, adaptivity could be provided. Within this thesis, a concept for recommending learning contents in LMSs was developed. This concept was implemented in the new Adaptive LMS, enabling adaptive LMS to automatically generate and suggest learning content that fit students learning styles. The LMS also allowed instructors and/or administrators to monitor learners learning styles and suggest learning contents based on the observed learning styles. This allowed learners to understand and strengthen their weak preferences. The LMS provided a convenient platform for managing course and course content in addition to adaptive capabilities.

5.2 Limitations

The limitations of this work can be seen as the number of participants that used the system and the availability of ongoing classroom courses. It might be interesting to confirm our results with students from different universities as test persons, or with university students from other majors. The implementation of automatic student modelling requires students ongoing interaction with the system, over time, in order to conduct accurate analysis of the learning information.

5.3 Future Work

The findings developed in this thesis can be used as the basis for further research and development regarding providing advanced adaptivity, especially in LMSs. Future work can focus, on extending the different parts of research conducted within this thesis. Regarding the automatic detection of learning styles, this thesis proposed a concept for automatic student modelling, which means that data are gathered over a period of time and then used to calculate learning styles. The conducted research can be seen as the basis for the development of automatic learning style detection approach, because the information about student's behaviour is processed immediately, and the student model is updated frequently. Future work will also deal with incorporating other learning style models, and other investigations regarding cognitive abilities and learning skills will be conducted.

Another area for research is to extend the LMS by incorporating more features. In the thesis learning objects included forums, outlines, exercises, examples, content and self-assessment tests. It would be interesting to incorporate other features such as navigation overview, this would help in making better inferences about learning styles.

Appendix A

Appendix one

The image of the physical model of the database showing tables with relationship(s) between them generated using MySQL workbench is shown below

.
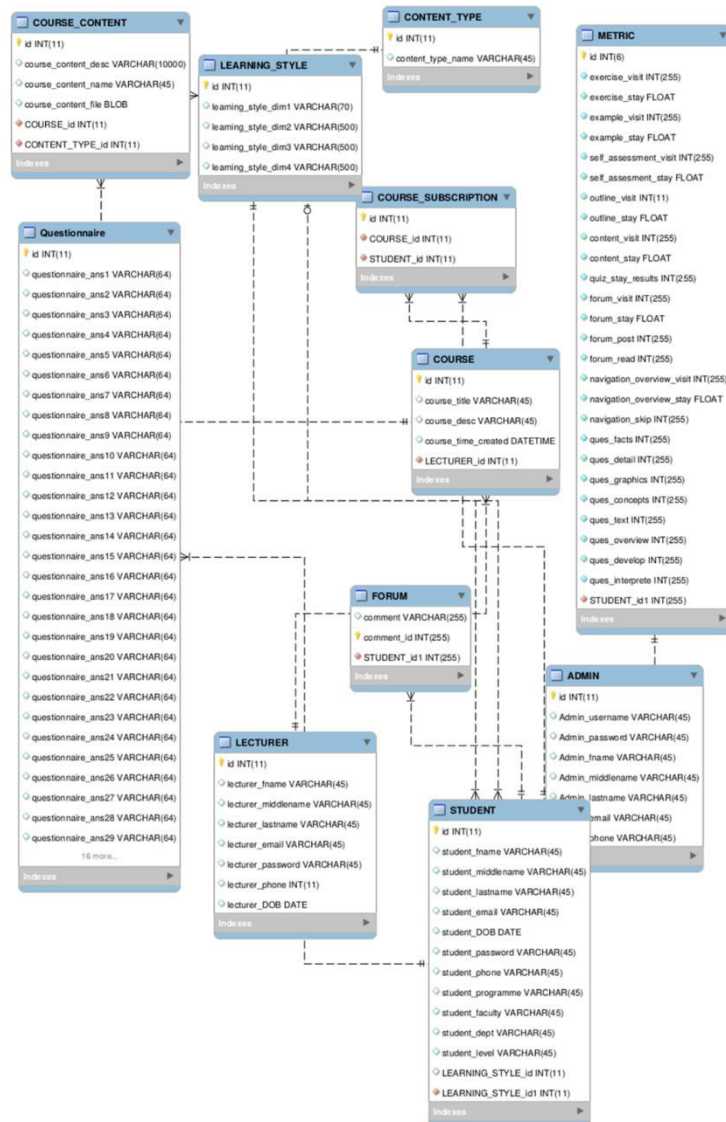
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