

The Presentation of Adaptive Contents Based on Felder Silverman Learning Style

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Abstract- Adaptive E-Learning is a latest trend in technology enabled learning paradigm. However the development of such specialized systems is a technology challenge which requires creativity and innovations. The content development is a basic building block of adaptive e-learning which is important for various kinds of learners that are unpredictable in competences and different in their preferences. The presentation to right content at the right time to the relevant learner can improve the knowledge level. Keeping in view of these challenges and opportunities, this paper presents a model of adaptive content based on Felder Silverman Learning Style (FSLM). The model covers the development of adaptive content and its presentation with respect to personalization based on their learning styles. The four dimensions of FSLM has been considered to develop the contents that includes audio, video, multimedia, text based tutorials and hands on activities. The presentation of content is initially based on learning style and then usage analyses which are programmed as a web based application. The performance of students is also analyzed to study the impact of adaptive contents. The experimental results show the improvement in overall performance.

Keywords- E-Learning, Adaptivity, Adaptive Contents Presentation, LS.

I. INTRODUCTION

The concept of E-Learning (EL) has evolved significantly over the past decade. EL systems are showed to be supported in providing strength to distance learning using information technology methodologies [1]. Due to some restrictions of collective dealings, learners must be kept themselves driven. The basic principle of E-Learning is the use of technology that provides online resources to the learners. It provides access to digital contents and renowned teachers that cannot be made available in a traditional environment. The advancement in E-

Learning settings brings us towards adaptivity based inventions that are more advanced learning systems. It can meet the student s' requirement by providing them the best possible environment/path to fulfill their dynamic needs of learning [2].

Adaptive property refers to the changing ability and therefore Adaptive E-Learning (AEL) are dynamic learning systems that change their appearance [3] on the basis of user Learning Style (LS), interaction and browsing history. Every AEL has basic common components like domain model, learner model and adaptive engine that work together. An AEL system constructs a frame work of the objectives, targets, priorities and knowledge level of every single individual learner. AEL systems [4-5] are those that adapt the Learning Material (LM) based on previous level of understanding about topic, skills of user, their learning capacity, profiles, preferences, personal interests and learning styles. Furthermore, adaptive content presentation refers to learning material that can be adapted according to the requirements of different learners [6].

Adaptive content presentation based systems are considered as advanced way of content presentation [7], that is capable of providing the tailored and matched learning content to diverse type of learners with heterogeneous LSs. Adaptive content has the ability to present itself according to the track of learner's activities and preferences even after categorizing their strength and weaknesses [8]. Adaptive content [9] presentation is maintained by a student model, which is constructed from student s' goals, preferences, learning style and knowledge. The development of such specialized system is a real challenge due to different learning styles and varying characteristics of learners. The generalized adaptive content presentational approach based model is the utmost need of the time for improving learning among the learners of 21st century. Prior to development of adaptive content based system, the learning styles were considered to be one of the core elements that should be considered [10].

The learning style is the process in which learners

interrelate, distinguish and respond in any learning situation [11]. Learning style can be characterized differently. The thought concerning about that the people have to be taught in a different way is accepted and have its beginning since the time of ancient Greeks [12]. The massive research was conducted on learning styles as it works as a bridge between learner, content and instructor for EL purpose [13]. It is the way or tendencies which are used to learn or review data by the student [14]. To achieve better results, the system should know which learning style is effective and suitable for its students [15]. Educational and learning operation can be enhanced only if suitable learning style(s) should be adapted according to student's capability [16]. Different learning styles are proposed by different researchers as Kolb [17], Honey & Mumford [18] and Felder & Silverman [19].

The reference [20] illustrates that, "the Felder Model is the most appropriate for hypermedia courseware". Reference [21] inveterate this by doing a contrast evaluation of different learning style models that proves it a suitable for AEL systems. Therefore in this research the Felder & Silverman learning style model will be used which have four scales of learning styles. These scales will be part of this research. The scales /parameters are

"Active/Reflective (A/R), Verbal/Visual (V/V), Sensing/Intuitive (S/I) and Sequential/Global (S/G)".

The paper is onward structured as: Section II contains the literature review; Section III presents FSLSM survey results obtained from the Allama Iqbal Open University (AIOU), Section IV presents the proposed adaptive model and covers its major components. Section V presents the experimental results that pursue by conclusion in Section VI.

II. LITERATURE REVIEW

The AEL has its roots from the 4 groups of theoretical approaches. These are "Macro & Micro Adaptive Instruction Approach (AIA), Aptitude Treatment Interaction (ATI) and Constructivist Collaborative Approach (CCA)" [22-23]. Reference [24] used Macro AIA to accomplish the learning objectives, reimburse flaws and expand novel ability and manner between the students. The advancement of the "Keller Plan Model" [25] is the significant work in the field of macro AEL systems that provides tailored instructions and LM to the diverse users till the level of mastery through its adaptive strategies and techniques. Reference [26] used the Micro AIA guidance approach to break down and check the students responses for adapting over the framework to adjust the instructive structure of the learning procedure. The method of dialogue and discussion based tutoring system is embedded as micro adaptive instructional approach through which the teacher constantly supervise the learning behaviors of learners in the way to regulate the

learning material and its pedagogy [22]. Additional researches on micro AIA models include: "Mathematical Model, Trajectory Model, Bayesian Probability Model, Structural and Algorithmic Approach" [24]. Reference [27] presents theory proved the base for ATI and projected a fundamental technique of choosing distinctive arrangements of learning content among learners to synchronize with their ability. The intellectual ability, cognitive style anxiety, prior knowledge and LS based features of ATI users are the main part of different researches [22][24]. The important distinctiveness of Constructivist Collaborative Approach (CCA) as performance investigation; social networking with community, interaction primitive, taking part in activities, dealings and transactions in a cluster etc are the best suited to machine effectual collaborative learning environment are described in [28].

Reference [22] proposed a Adaptive E-Learning with Eye Tracking AdeLE model that adopting the macro adaptive technique in designing instructional objects for domain model these instructional objects and elements are like guidelines, modules, addresses, courses and so forth. Reference [29] proposed AAels "Automatic Adaptive e-learning system" framework to find out information level and learning inclination changes of student while the student is busy in dealing with domain model. The adaptive engine is performing two tasks; one is based on feedback questionnaire data; and other one relates to online interaction of student with learning content. Reference [30] proposed Adaptive Web Model for Gamification that is sub divided into 4 dimensions that are Who, Why, How & What. All correlates with basic components of ALE that explains the complete procedure of the model. The reference [31] proposed an "adaptation criterion for customized/personalized learning material". The model approves and authenticates it by utilizing both of quantitative and subjective research methods. The model has considered thirty (30) adaptive systems that were validated by two online surveys conducted from experts. The major result of proposed criteria finally focused on the necessary adaptation requirements of students for presenting appropriate LM.

Reference [32] illustrates the learning highlights the individual's way of observing and handling information in diverse ways. Reference [29] says, "Learning style reflects our preferred manner of acquiring, using and thinking about knowledge". The Learners can differentiate by various learning styles specially concentrating on various kinds of data and having a tendency to work on perceived data in various ways [23]. Every individual has its own and different techniques for handling the circumstances. Mostly learning style based models categorize students into a couple of groups, though Felder & Silverman explain the learning style in distinctive manner according to needs and inclinations of local learners.

There are various learning style models including the Dunn and Dunn model [33], Keefe [34], the MBTI (Myers and McCauley) [35], Honey & Mumford [36] and VAK [37], Felder & Silverman [26], Kolb [24]. Each of them proposed different ways of learning styles. All are trying to produce the tailored learning material based on student learning style. Reference [38] describes the content model that conceived from Felder & Silverman model which based on the students interest and their learning styles.

So, there is a need to build up a specific adaptive content which synchronize with the learning style of a student. To achieve this purpose we have to plan, design and deliver the specific adaptive content that satisfies the learning necessities of student individually in AEL scenario. Felder–Silverman Learning Style Model (FSLSM) created by Felder & Silverman [39] is the most suitable for developing adaptive content based learning systems [16][38]. Felder & Silverman [19] introduced a well-known LSM (learning style model) for engineering students. The learning style is used for discovering learning inclinations/needs of engineering students and teaching method that best matched with each dimension of learning styles model. FSLM is considered important due to its implementation and experimentation on engineering students. While many other models classify students in couple of groups, whereas FSLSM recognizes the learning style and recognizes inclinations on four measurements and dimensions [39]. These dimensions are (A/R), (S/I), (V/V), and (S/G) with 16 possible combinations of learners [40]. Each learner has its specific preferences related to these four dimensions [41].

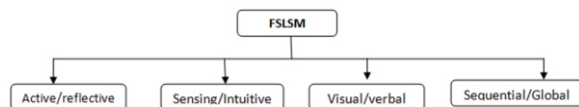


Fig.1. Felder & Silverman Learning Style Model

Reference [42] using ILS (index of learning style) of FSLSM for designing a learning system in which the four dimensions are correlate with three-cohort like undergraduate e-learner, graduate e-learner and e-educator. Vassileva [43] presents an adaptive model and plate form architecture of e-learning system using FSLSM that demonstrate the learning material depends on student learning style and level of knowledge. Reference [44] Introduces reusability of learning objects in adaptive scenario based on FSLM by using LMS to organize the learning material. Reference [45] introduced the learning style based adaptive system for success in getting ICDL (international computer driving license) certificate of computer skills. Reference [46] describes the procedural steps of getting data regarding learning styles of students using FSLM and also supporting runtime adaption of learning objects by “per visit” and “time span” for each

dimension.

Cs383 is additionally one of the important frameworks that personalized learning content associated with an e-course, considering the learning styles [20]. Reference [47][48] proposed ILASH model that stands for “incorporating learning strategies in hypermedia”. In it the adaptive navigation techniques are used for links to e-content, which can be enabled or disabled and advancement to next topic happened after obtaining perfection level and check points. As for the review of AE systems, the HCI (human-computer interaction) have been mostly reviewed by Gena [49]. The TSAL framework takes into consideration of student communications with the AEL system and learning style for presenting the relevant customized content of mathematics course [50].

Research studies related to learning styles has produced undersized scale and short-term based ITS on LS detecting models for limited number of sample size [51][52][53][54] but the elementary information is generally produced with online user interaction with learning elements for personalization [55]. Alshammari [56] developed an adaptive model and architecture of AEL system that presents the learning material depends on student LS and level of knowledge using FSLSM.

The aim of this paper is to investigate the LS using Felder & Silverman learning theory and select appropriate learning content to deliver for E-Learner in order to facilitate the learner to present the content according to his/her LS and convenience. The literature review shows that the theory of Felder & Silverman LS is significant due to many reasons. It is very effective model for AEL systems [57][58]. Furthermore, they gave the thought for taking an attempt at interchange instructing techniques like progression of exercises and asset designation to learners [39]. The FSLSM is more appropriate for developing adaptive content presentational learning systems [20][38] and even the theory established the innovative aspects on learning styles and procedures for science and engineering students.

III. LEARNING STYLE AND PREFERENCES OF LOCAL LEARNERS

E-learning can be progressively more practicable in the event if it is adjusted to the necessities of students. In this manner, before building up the AEL system, students are explored to find their preferences, interests and learning styles for providing appropriate learning material. For this purpose using FSLSM survey questionnaire that is disseminated among the students of Bachelor of Science in Computer Science BS (CS). The CS program is chosen because CS students have the capability of utilizing and handling computer software's. In addition, the CS selected course has an opportunity of introducing EL method of instruction for urban, semi urban and provincial regions of the

Pakistan. These replies are examined and results are given below.

A. Demographics

The demographic statistic results demonstrate that

TABLE I
STUDENT'S DEMOGRAPHIC DATA

VARIABLES	FREQUENCY
Gender	
Male	57
Female	23
Age Group	
Less than 21	20
21-30	50
31-40	10
More than 40	00
Location	
Urban	60
Semi Urban	12
Rural	8
Program of Study	
BS(CS)	80
PGD(CS)	00

57 % of respondents are male and 23% are female with mainstream of respondents in the age limits of 21-30 years as mentioned in Table I. Most of the respondents (60%) are living in urban regions, though 12% in semi-urban and 8% in rural regions.

B. Learning Style

The initial learning style evaluation is analyzed by using Felder and Silverman questionnaire that supports to produce first screen of adaptive content according to student LS. The questionnaire of Felder and Silverman is consisted of 44 items and set of 11 items are belongs to its specific learning dimension. These are A/R, S/I, V/V, S/G as given below in table II.

There are 60% students belongs to Active, 40% to Reflective, 55% to Sensing, 45% to Intuitive, 56.25% to visual, 43.75% to Verbal, 58.75% to Sequential and 41.25% to Global dimension of FSLSM. The p-value shows the positive significant relation between each dimension of FSLSM.

TABLE II
STUDENT'S LS DATA

Learning Styles	Frequency		Frequency %		Chi Square		P-Value
Active/reflective	48	32	60%	40%	0.26086	13.6	0.000
Sensing/Intuitive	44	36	55%	45%	25.3	15.3	0.0000
Visual/verbal	45	35	56.25%	43.75%	25.875	14.875	0.0000000001
Sequential/global	47	33	58.75%	41.25%	27.025	14.025	0.0000000002
Mean	46	34	0.575	0.425	-	-	-
S.D	1.825742	1.825742	0.022822	0.022822	-	-	-

IV. PROPOSED MODEL

This section is presenting our proposed model. The proposed model depends on the discoveries of study led to examine the profiles, preferences and learning styles of the students as shown in Section III. The proposed adaptive content presentational model, as appeared in Fig. 2 is conceptualized in the point of view to design and deliver the adaptive content(domain model) using web based application interface that suits with the needs of local learner's profiles and LS(student model). The AEL is adaptable and intelligent in nature. It encourages the student enrollment in course by using adaptive techniques and algorithms for presenting learning material based on student LS. Adaptive engine is providing facility to find initial LS and onward updation of student's preferences in student model. Explanation of components is given below:

A. Domain Model

The Domain Model is the major module of our proposed model. It is made out of data about program, curriculum and courses etc as shown in fig. 3. Each course is subdivided into chapter/units that further alienated into topics and subtopics in sequential manner. The Course is structured with its content breadth/depth and difficult to easy conceptualization by using sequential feature of content making. The granularity level is characterized in "n" levels which is the optimal degree of granularity in form of its breadth and depth. All learning material is fetched from data repository called metadata.

Learning material is presented, based on 4 dimensions of FSLSM in different formats after detecting and analyzing the student learning style shown in table III. The formats include text, audio & video aids and hands-on-based exercises etc.

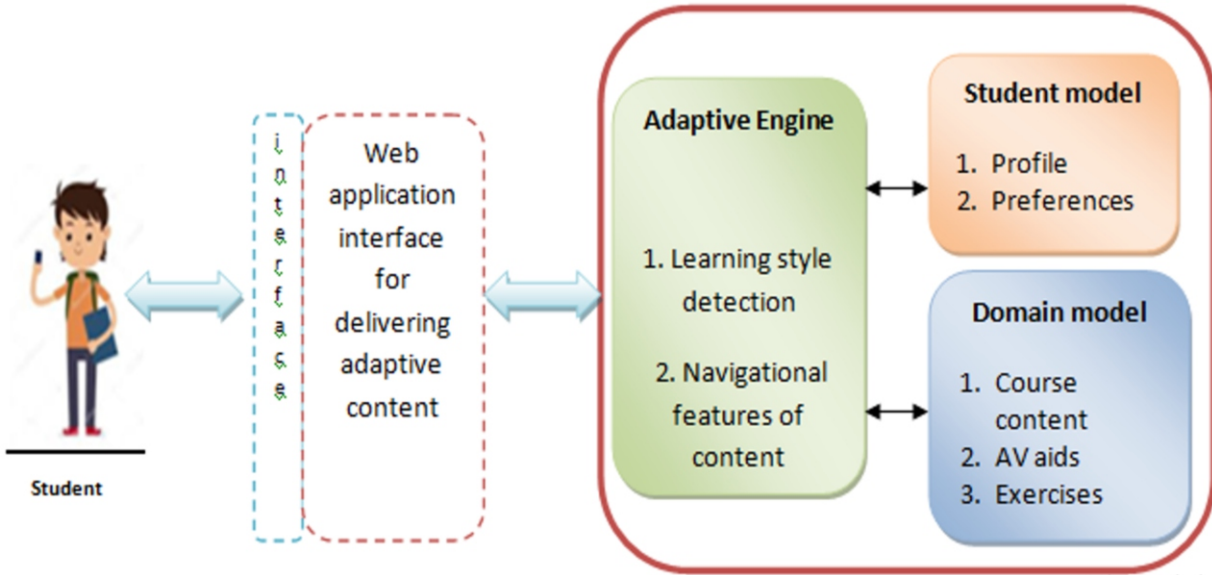


Fig. 2. Proposed Model

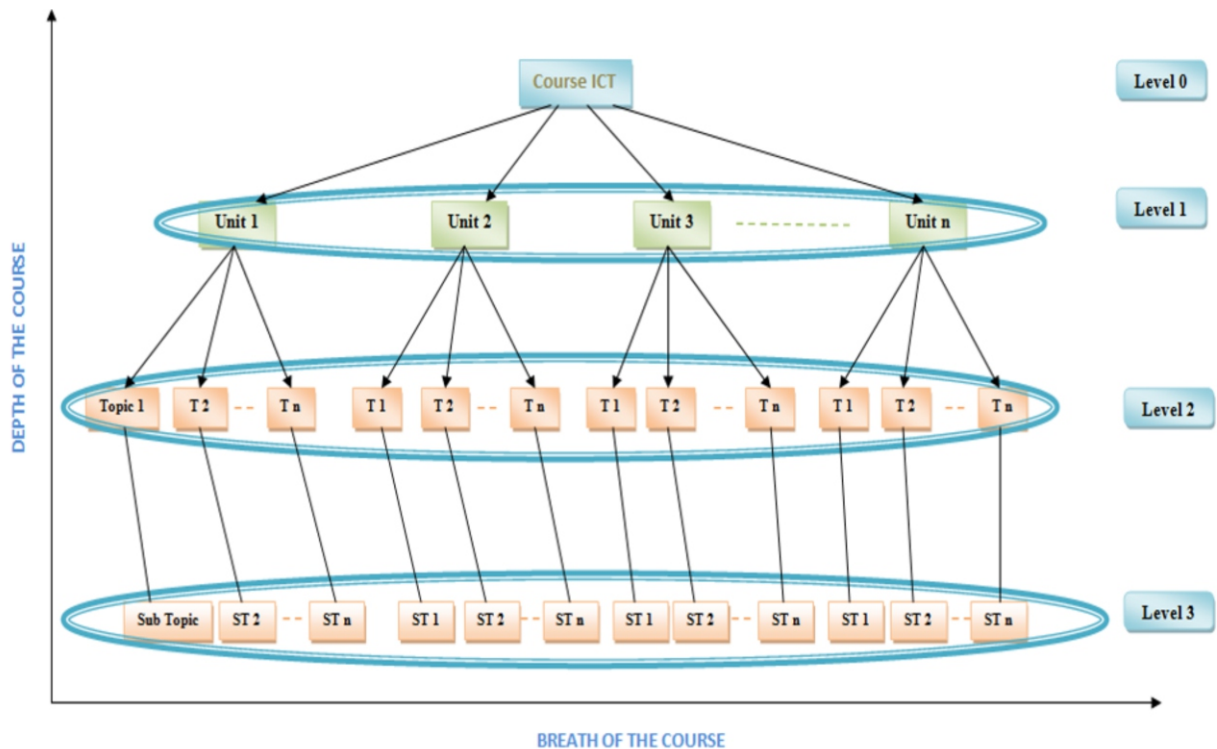


Fig. 3. Course Structure

Diagrams, tables, graphs are used to provide more strength to learning material and its concepts delivered. The chapters are instructional details that clarify the key ideas of a course. It is composed of a progression of pages connected by means of hyperlinks that continuously build up the concepts. The chapters are composed as site pages associated through hyperlinks using bootstrap framework. Videos lessons are created through a blend of content, sound, and animation. They

are utilized to encourage learners with visual learning style. Hands on exercises are composed of activity pages that are utilized to help the learners of active LS. They are created to give the learner a chance to learn ideas and concepts practically. The students can learn by going through hands-on-exercises for better understanding of topic. It empowers them to apply activities on different ideas and circumstances by utilizing their basic reasoning capacity.

TABLE III
ADAPTIVE CONTENT BASED ON FSLSM

DIMENSION	LC PROVIDED	NATURE
Active	Hands on exercise, audio, video, text and exercise	Active learner, Learn By doing.
Reflective	audio, video, text, exercise	Passive learner, learn by thinking using visual/verbal learning material.
Sensory	Audio, video, text, exercise	Concrete learner, learn by audio and videos, text with images and real life examples.
Intuitive	Text, audio, video, exercise	Abstract learner, learn by theoretical explanation in form of abstract summaries of topic and course, visuals.
Visual	Videos, images, diagrams, text, exercise	Visual learner, learn by Visuals overview.
Verbal	Audio lectures, text, exercise	Verbal learners, learn by theoretical explanations, audio narrations and text overview.
Sequential	Sequential Next button, video, audio, text and exercise in pedagogical manner.	Visual/verbal sequential learners learn by Visuals, theoretical explanation but sequentially organized.
Global	Direct links, Video, audio, text and exercise	Visual/verbal global learners learn by Visuals, theoretical explanation in broader aspect without connections.

Audio and video based learning material is presented in MP4 format. The given above table is mentioning FSLSM's dimensions along its nature and related learning material provided in the research [59-62].

B. Student Model

Student Model is the major module of the AEL. The model is designed to gather data/information about learner. The information is collected in two parts; demographic and learning preferences/LS. Demographic information that is comprised of the name, gender, ages, roll number, program of study, location, job status and having internet facility etc. while learning preferences related data was gathered by using FSLS survey for predicting student initial learning style and onward change in learning preferences.

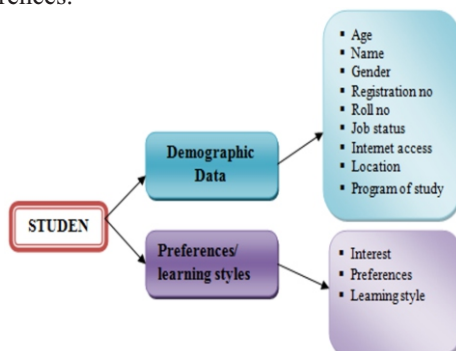


Fig. 4. Student Model Compositions

The details of Student's Model are as follows.

i. Initializing Phase

In this phase the student registers his/her self and fills the Felder & Silverman ILS (Index of Learning Style) questionnaire of 44 items. After every login, the tailored e-content based on student learning style predicted after analysis of 44 question items, is presented to learner.

ii. Updating Phase

The “student model” is updated by analyzing the browsing activities of learner after first login till the specified time period. The model renews the user interface of the application using ITS approach.

C. Adaptive Engine

Adaptive engine facilitates the user by fetching the learning material based on LS, preferences and online browsing into two modules. The Engine collects data of initialization and updation phases and analyzes them through the learning algorithms.

The first algorithm DFD shown in fig. 5 receives the data; an analysis is performed by the Adaptive engine to find the initial LS of the learner to design the dynamic screen. The screen displays the output by picking suitable learning material from metadata repository based on the results of analysis. The second algorithm DFD shown in fig. 6 recorded the link access clicks and per visit to each learning content by student into database for analyzing his/her changing attitudes

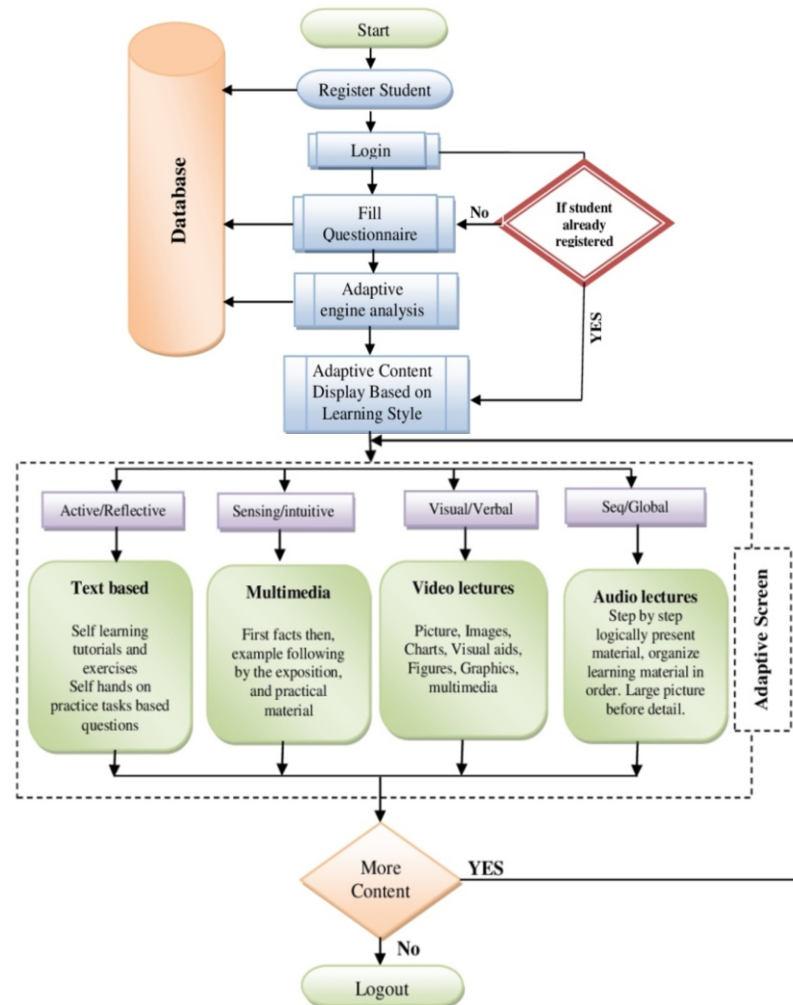


Fig. 5. Initializing Phase DFD of Adaptive Content Presentation Module

toward learning style. The complete procedure can be explained by two DFDs of Initializing and Updating Phase of Adaptive Content Presentation Modules given above.

Adaptive Engine performs analysis on the data received in the form of answers to 44 questions of FSLSM which is divided into 4 clusters having 11 items each. 4 clusters represent each dimension in FSLSM. Every question has two choices **A** and **B**. Adaptive Engine sum up the rate of choices selected for each question in a cluster. Lower value is subtracted from higher value. The resultant number is concatenated with the choice letter of higher value. This gives level and LS dimension to Adaptive Engine. As a result, system presents Adaptive Content to the learner based on his/her LS.

There is another module which is used to update the student model based on runtime navigation in the application. The interest of student and link access clicks are recorded into the database, in form of per visit to each learning material. This access log is analyzed by

the adaptive engine to calculate the changing attitude, interest towards learning material etc. As a result, a balanced and requisite new adaptive screen is presented to the student. Summing up the visits/clicks to each learning object that should be greater than the counts of all other learning elements in a particular time period is given in the following formula.

$$NS = \sum VLO (SLSD) > \sum VLO (ALE)$$

Where:

NS = New Screen

VLO = Visit to Learning Object

SLSD= Specific Learning Style Dimension

ALE = All other Learning Elements

There are only 10% students tends to the other dimension of FSLSM and 90% restrain their Initializing phase's mentioned LS.

In next section, we will discuss the experimental results that support the considered Parameter's impact statistically on learning of local learner.

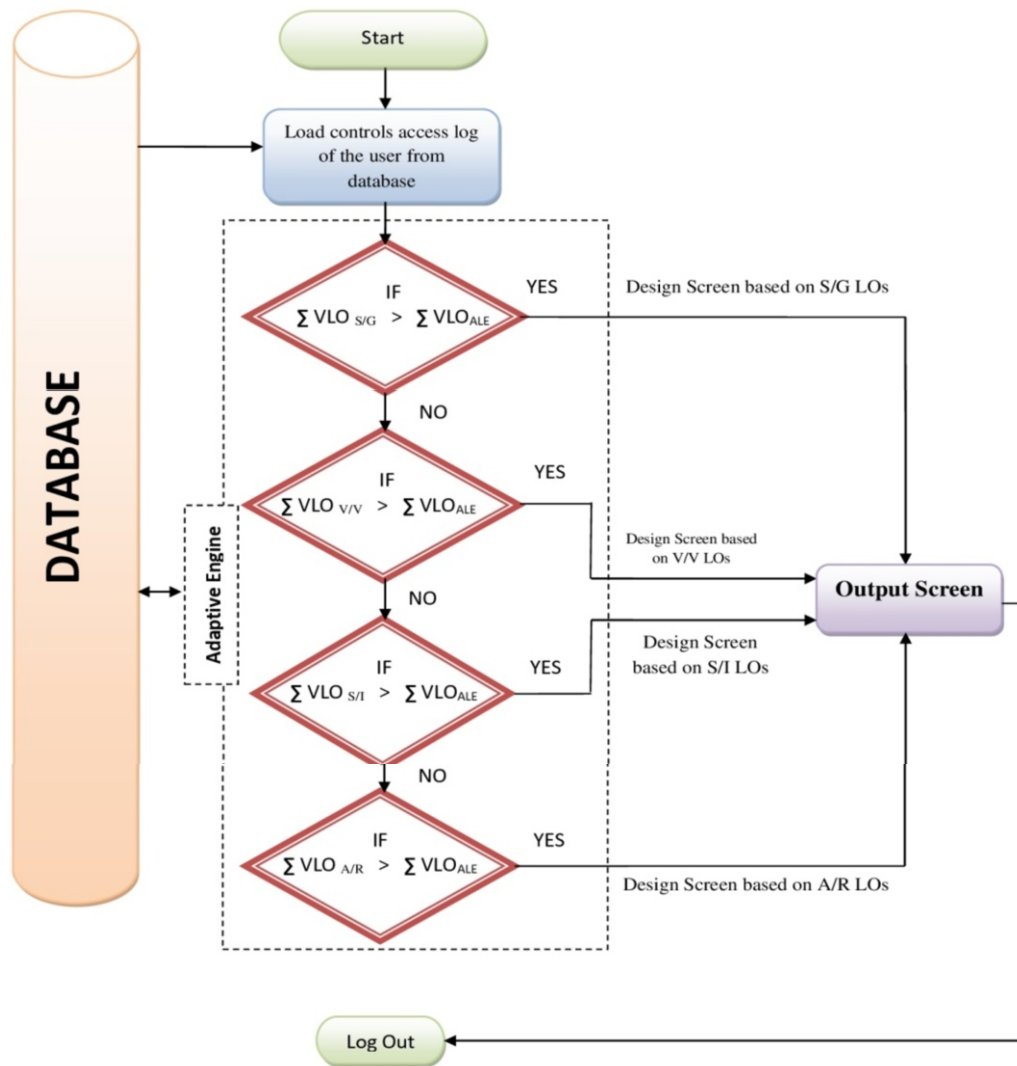


Fig. 6. Updating Phase DFD of Adaptive Content Presentation Module

V. IMPLEMENTATION AND EXPERIMENTAL RESULTS

The prototype is developed that manages student data/preferences and course content using DB server and content/file server. Microsoft SQL server 2008 R2 is used as backend database server to store the data of Initializing and updating phase's algorithms. Whereas all data files are stored on a file server which is responsible for the central storage and management of data files. The application is developed using ASP.NET in Microsoft Visual Studio 2017 which communicates with an external metadata server using RESTful (Representational State Transfer) web API protocol. The RESTful web services have been exposed using "Internet Information Services" web server. The interface is designed using web framework called Bootstrap version 4.0 which has made it responsive. The application's interface is composed of buttons,

links and text. Students access the adaptive content by registered them. Student can access the registration screen by clicking the Register button on the home interface. Successful registration will create an account for the student. With the help of Login button, student can login to the application and get adaptive content based on their LS as per adaptive algorithm.

The Proposed model is implemented on Basics of ICT course of BS (CS) program at Allama Iqbal Open University (AIOU). To check the impact of AEL based content on the exam results of the students. Therefore overall result comparison is made in fig. 7 among three different batches (2016-2018) as control groups of the same course and experimental group (2019) to whom the adaptive navigational content based application was provided. The sample size of population depends on the total enrollment of students in all batches of AIOU. The results are mentioned in 'percentage of marks' in final assessment.

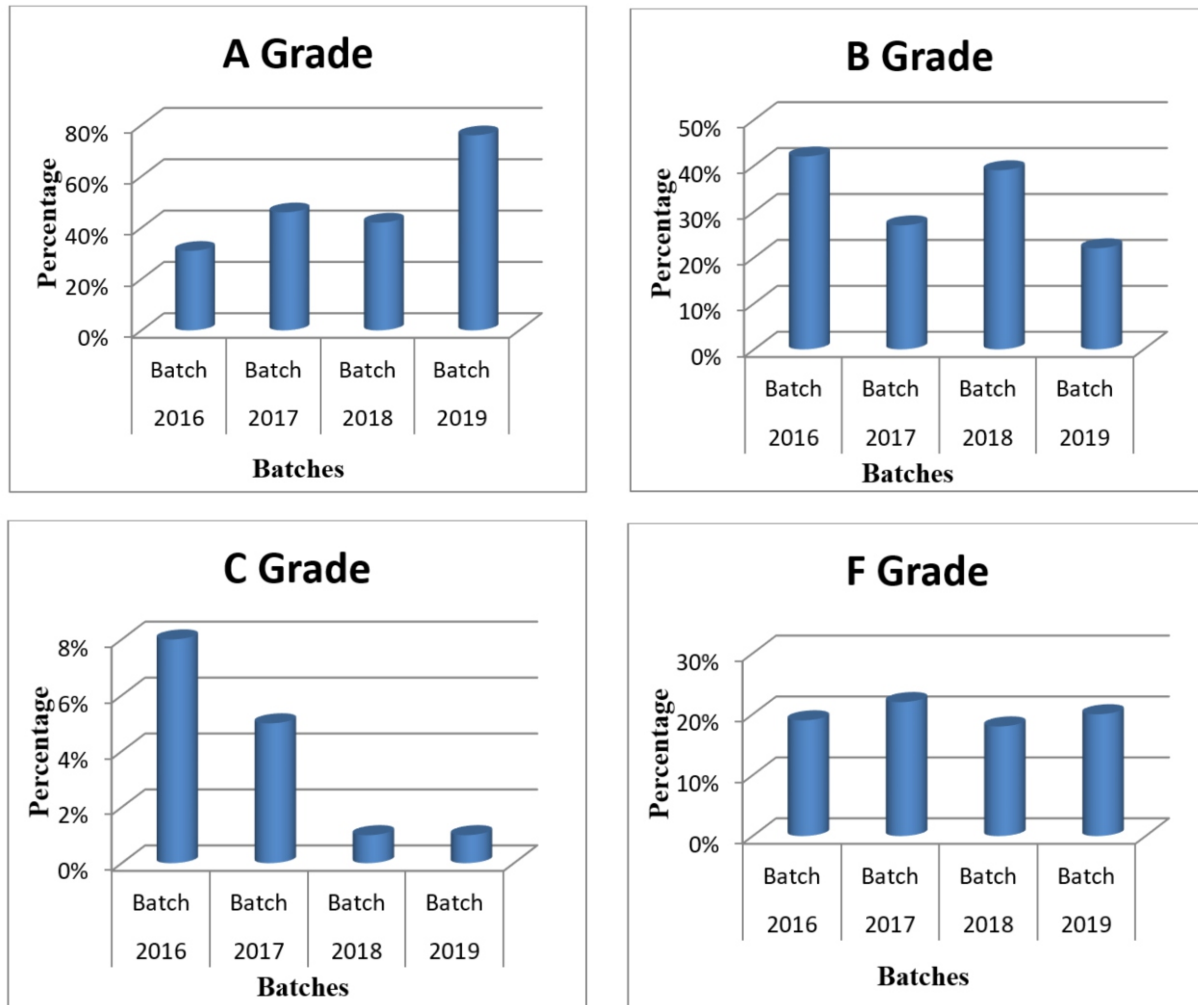


Fig.7. Result Comparison of Four Groups

Data from last three years is taken into consideration for comparison with recent year i.e. 2019.

The overall comparison of results shows that almost 76% of students gained A grade in 2019. It is the highest value if we compare it with previous years. Whereas adaptive navigational content based application is newly introduced to the students who are not much familiar with it. The adaptivity, user-friendly interface and analysis of runtime navigational data features make it easy for students. That's why the results of student (obtaining A grade) are extraordinary.

B grade marks are on the second position. The number of B grade obtainers are reduced as the great difference can be seen in increasing numbers of A grade holders. Mostly B grade obtainers are succeeded in obtaining A grade. Grade C percentage is 1%. It is comparatively decreased by previous years. Introduction of adaptive navigational content software shows that the number of C grade is reduced which is an improvement. The grade F results are in middle which shows the increasing

interest of learners towards AE system.

VI. CONCLUSION AND FUTURE WORK

Contribution of this research is the development of a generalized model for preparation and presentation of adaptive contents for technology courses. The development of contents is based on FSLM theory of learning styles. The type, format and presentation are mechanized by using initialization and updating of student models. The model has been demonstrated by developing the specialized contents for a Computer Science course and its presentation using a web based application. The test results have discovered that the AEL method has verified in form of optimistic influence and impact on student understanding towards learning material. The overall results and performance of the recent batch in comparison of previous once are much improved and the dropout rate also reduced.

In future the more adaptive presentational and navigational techniques will be introduced /embedded in more courses to improve the performance of students.

VII. ACKNOWLEDGMENT

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