Modified Literature Based Approach to Identify Learning Styles in Adaptive E-Learning

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Abstract. To effectively understand the adaptation approaches in content delivery on E-learning, learner's learning styles need to be identified first. There are two main approaches that detect the learning styles: Questionnaire based and Literature based. The main challenge of Adaptive E-learning is to capture the learner's learning styles while using E-learning portal and provide adaptive user interface which includes adaptive contents and recommendations in learning environment to improve the efficiency and adaptability of E-learning. To address this challenge the literature based approach requires to be modified according to learner's usage of e-learning portal and should generate learner's profile according to standardized learning style model. The study focuses on engineering students and the learning style model considered is Felder-Silverman Learning Style Model. The paper presents the analysis of log data which is captured in log files and database. Analysis of obtained results show that the captured usage data is useful to identify the learning styles of the learners and the types of contents is proved important factor in literature based approach.

Keywords: Adaptive E-learning, Felder-Silverman Learning Style Model, Web Logs, Behavioral Model.

1 Introduction

The evolution of E-learning is focusing mainly on adaptation in education. Each learner has his/her own learning style which indicates how he/she learns most effectively from courses. Adaptive E-learning system allows students to learn by themselves so that it would improve learning effect and overcome the problems of traditional learning.

Effective Adaptive E-learning has different adaptation approaches which mainly focus on content delivery and adaptive user interface on E-learning portal. Main input factor to adaptation approach is learner's learning preferences which should be captured according to standard learning style model. There are two main approaches that detect the learning styles: Questionnaire based and Literature based [1], [2].

In questionnaire based, learner's learning preferences will be captured by analyzing the responses made to the questions. The problem with this approach is that sometimes it will produce inaccurate result and is not capable of tracking the changes in learning styles. Literature-based approach is a new methodology which is depends on learner's interaction towards learning portal. The dynamic nature of learner's learning styles can

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be captured using this approach. Support of learning style model is making this approach efficient and accurate.

Several learning style models have been proposed by Myers-Briggs, Kolb and Felder-Silverman out of which Felder-Silverman Learning Style Model (FSLSM) focuses specifically on aspects of the learning styles of engineering students and it is successfully been proved in questionnaire approach and as a behavioral model in literature based approach. Learning styles represent a combination of cognitive, effective and psychological characteristics that indicate the learner's way of processing, grasping, understanding and perception capabilities towards the course contents.

The paper discusses about the Prototype version of e-learning portal which has been designed and developed to test the proposed framework of e-learning for identifying learning styles of learners. It is based on the different types of contents and nature of page visits in order to modify the literature based approach.

2 Related Works

Grapf *et al.* [2] discussed about Literature based approach where authors have analyzed the behaviors of 127 learners for object oriented modeling course in Learning Management System (LMS) moodle using Felder-Silverman Learning Style Model. Behavior patterns associated with thresholds are determined according to learner's activities. In this paper, authors have done the experimentation on moodle which is a static web portal that supports only static user interface for all learners.

Literature based approach of detecting learning styles in e-learning portal is mentioned by P.Q.Dung *et al.* [3]. Literature based approach is modified with multi-agent architecture where learning styles of the learners have been identified by conducting tests and storing it in a database. Later different types of contents are provided to learners and monitored as to identify whether the learning styles are changing as per the behavior or not. The mentioned approach is time saving but static in nature where the students learning styles are changing depending on structure of the course and learner's interest. Also the learning material is not divided into content types based on FSLSM.

Salehi *et al.* [4] have addressed the recommendation of course material for e-learning system. Authors have mentioned the content based recommendation and similarity based recommendation. However the learner's profiles have not been classified based on learning styles which is the main factor of recommendation with respect to learner's individual preferences.

The Web-based Education System with Learning Style Adaptation (WELSA) described by Popescu *et al.* [5] which is an intelligent e-learning system. It adapts the course contents to the learning preferences of each learner. Authors have considered different learning objects as a Resource Type (e.g. Exercise, Simulation, diagrams and experiment etc.) and not focused on different types of learning contents where learners are trying to get knowledge by understanding and processing the contents with supportive resources.

Liu *et al.* [6] have described combined mining approach of web server logs and web contents. The approach is useful to facilitate better adaptive presentation and navigation as a part of Adaptive E-learning system. The mentioned novel approach of combination is useful to find out the user navigation patterns and page visiting sequences.

Evolution and new trends of learning systems are reviewed in the context of learning paradigms and methodologies by Simi *et al.* in [7]. Authors have given overview of personalization as a learning process which is closely related to recommendation and leads to the adaptation in contents on e-learning portal based learner's preferences.

3 Methodology

The main objective of proposed work is to identify the learning styles using web usage mining in literature based approach. A work is carried out by capturing the access patterns of the learners in W3C extended log formats and in database. The W3C log files give the usage of different pages accessed as per the learners login and page visit sequence. The database log gives the usage of different files accessed as per the course contents and time spent on that page.

3.1 Felder-Silverman Learning Style Model (FSLSM)

The model adopted is the one suggested by Felder and Silverman (1988) for engineering education, which classifies students according to their position in several scales that evaluate how they perceive and process information [8], [9]. The initial levels of parameters considered according to the FSLSM are shown in Table 1. The parameters for specific learner can be captured in web logs of E-learning Portal. The captured logs can be further analyzed to modify literature based approach. Based on analysis the learners can be classified into FSLSM categories.

Table 1. Parameters for FSLSM

Contents	Act	Ref	Sen	Int	Vis	Ver	Seq	Glo
Text		X		X		X	X	
Videos		X	X	X	X	X		
Demo/PPT		X	X			X		X
Exercise	X			X				
Forum	X			X				
Index of Topics	X		X					X

3.2 E-learning Framework

Adaptive E-learning is dealing with educational systems that adapt the learning content as well as the user interface with respect to pedagogical and didactical aspects. The framework shown in Fig. 1 explains about the approach of Adaptive E-learning portal where the first step is to recognize the learning styles of individual student according to the actions or navigation that he or she has performed on portal using Web Usage Mining(WUM). Web log mining is substantially the important part of WUM algorithm. It involves transformation and interpretation of the log information to predict the patterns as per different learning styles using optimized clustering technique. Ultimately these patterns are useful to classify various defined profiles depending on content types.

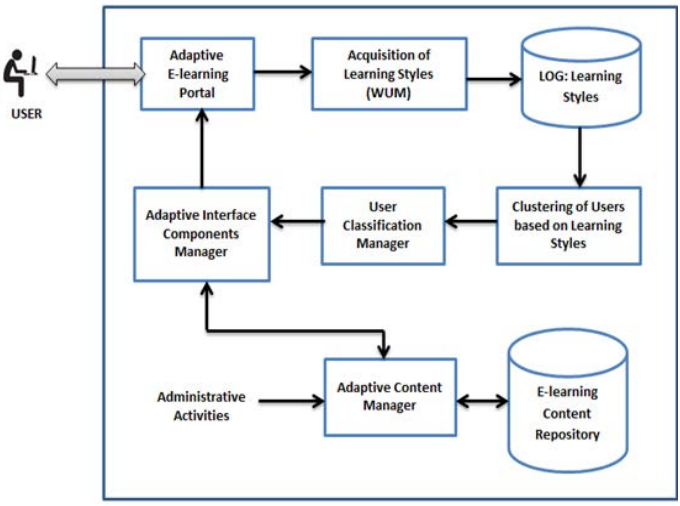

Fig. 1. Framework of E-learning

The clustered learner profiles with learning patterns are the input for user classification manager. Here classification algorithm can be used to identify different kind of learners based on the learning style of Felder and Silverman Model. After identifying the categories of learners the Interface component manager is changing the graphical representation of user interface based on small applications of e-learning portal. The contents of e-learning should be adaptive enough to change the interface components according to the learning style. This adaptive interface components can be generated using adaptive contents based on user classification with the help of administrative activities and e-learning content repository. This content is an important input factor for Interface Component Manager (ICM).

The paper describes about the approach of learning styles acquisition through usage log data of e-learning portal and the detailed analysis of log data.

4 Experimentation Details

According to the framework mentioned in Fig. 1, implementation of e-learning portal has been started using Microsoft Visual Studio 2008 and Microsoft SQL server 2005. The portal is deployed on IIS server to provide access to all learners in the Intranet. The log file option of IIS server is set to W3C extended log file format for the portal which will capture usage details of learners who are accessing the portal.

The prototype version of portal is made accessible for First year engineering students for Problem Solving Using Computers subject with the following topics: Arrays, Strings and Pointers.Each topic is made available for study in different file formats such as text (doc/pdf), video(mpeg/mp4) and demo (ppt/pptx). Also an exercise on 1D array, 2D array and Strings for learners is generated. Around 75 learners have registered in portal out of which 30 learners have accessed the topics which are mentioned above. The log

files of learners who are accessing portal are maintained in W3C log file along with the time spent and access details of files are captured in database against the specific session of the learner.

5 Experimentation Design

In this work, we have designed an experimental algorithms to analyze the records of usage which are captured in log records and database. In the following subsections the algorithms of the system are described in detail [10], [11].

1. **Session Identification of Learner:** Session can be described as the time spent on portal by a learner from the moment he/she logged in to the moment he/she logged out. So session identification of learner is the process of collecting individual access sessions of each learner from the log records and accumulate it to get total session time. Algorithm 1 is used to get total session time of each and every learner on portal.

Algorithm 1. Total time spent on the portal by user

INPUT: A finite set of Learners $L = L_1, L_2, ... L_N$ and Sessions $S = S_1, S_2, ..., S_Q$
OUTPUT: $Session_{Time_j}$ = Time spent on portal in one session and $TotalSession_{Time_i}$ = Total time spent on portal by one Learner in Different Sessions

initialize $Session_{Time_j} \leftarrow 0, LogIn_{Time} \leftarrow 0, LogOut_{Time} \leftarrow 0, TotalSession_{Time_i} \leftarrow 0$
for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
  for *each Session* S_j where $j \leftarrow 1$ **to** Q **do**
    if L_i *is logged in* **then**
      $LogIn_{Time} \leftarrow t$
    end if
    if L_i *is logged out* || L_i *idle for threshold time* **then**
      $LogOut_{Time} \leftarrow t'$
    end if
    $Session_{Time_j} \leftarrow LogOut_{Time} - LogIn_{Time}$
  end for
  $TotalSession_{Time_i} \leftarrow TotalSession_{Time_i} + Session_{Time_j}$
end for

2. **Content Identification:** Content identification is analyzed by calculating the time spent on specific file in one all the sessions of that learner. Since sessions are segmented between many sub sessions, time spent of specific file in one session of the learner is need to be considered first. The detailed steps are given in Algorithm 2.
3. **Content Type Identification:** Content type identification is useful to understand what type of contents learners are more interested in. It is analyzed by calculating the frequency of accessing specific type of file by all learners. There are three types of contents are available on portal i.e. pdf, ppt and mp4. The Algorithm 3 describes the steps to identify frequency of each file type which is accessed by a learner in all sub sessions.

Algorithm 2. Total time spent on specific file by user in all the sessions

INPUT: A finite set of Learners L = $L_1, L_2, ..., L_N$ and Sessions S = $S_1, S_2, ..., S_Q$
OUTPUT: $TFile_j$ = Time spent on specific file in one session and Total $Duration_i$ = Total time spent on a specific file in all sessions by Learner L_i
initialize $End_{Time} \leftarrow 0$, $Start_{Time} \leftarrow 0$, $TotalDuration_i \leftarrow 0$, $TotalSession_{Time_i} \leftarrow 0$
for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
  for *each Session* S_j where $j \leftarrow 1$ **to** Q **do**
    if *"File" is accessed* **then**
      $Start_{Time} \leftarrow t$
      {t is the system time at Learner clicked}
    end if
    if L_i *is clicked back button* || L_i *clicked other link* || L_i *idle for threshold time* **then**
      $End_{Time} \leftarrow t'$
      {t' is the system time at Learner unclicked}
    end if
    $TFile_j \leftarrow End_{Time} - Start_{Time}$
  end for
  $TotalDuration_i \leftarrow TotalDuration_i + TFile_j$
end for

Algorithm 3. Number of times a specific type of file accessed by learners

INPUT: A finite set of Learners L = $L_1, L_2, ..., L_N$ and Sessions S = $S_1, S_2, ..., S_Q$
OUTPUT: Frequency of accessing specific type of file
initialize $FileType \leftarrow NULL$, $Freq_{PDF} \leftarrow 0$, $Freq_{PPT} \leftarrow 0$, $Freq_{MP4} \leftarrow 0$
for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
  for *each Session* S_j where $j \leftarrow 1$ **to** Q **do**
    if *"File" is accessed* **then**
      get FileType
      switch *FileType*
      case "*pdf*" :
      $Freq_{PDF} \leftarrow Freq_{PDF} + 1$
      break
      case "*ppt*" :
      $Freq_{PPT} \leftarrow Freq_{PPT} + 1$
      break
      case "*mp4*" :
      $Freq_{MP4} \leftarrow Freq_{MP4} + 1$
      break
      end switch
    end if
  end for
end for

4. **Topic Identification:** Topic identification portal can be analyzed by counting the number of times the specific topic is accessed by all learners in all their respective sessions. Algorithm 4 is used to calculate the count of specific topic.
5. **Page Identification:** Algorithm 5 is used to calculate the count of specific page accessed on portal. There are many different pages available on portal which are related to learner's requirements. Page identification will give count of specific page accessed by learners. These details are useful to get the usage patterns of the learners with respect to portal.

The analysis has been done on IIS log records and Database and result has been discussed through different graphs in next section.

Algorithm 4. Number of times learners accessed specific topic

INPUT: A finite set of Learners L = L_1, L_2,...., L_N Topics T =T_1, T_2,...., T_M and Sessions S =S_1,S_2,...., S_Q
OUTPUT: T_{ik} = Number of times one Learner accessed specific $Topic_k$ in all sessions $TopicCount_k$ = Number of times all the Learners accessed specific $Topic_k$

initialize $T_{ik} \leftarrow 0, T_{ijk} \leftarrow 0, TopicCount_k \leftarrow 0$
for *each Topic* T_k where $k \leftarrow 1$ **to** M **do**
  for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
    for *each Session* S_j where $j \leftarrow 1$ **to** Q **do**
      if *Topic* T_k *is accessed* **then**
        $T_{ijk} \leftarrow T_{ijk} + 1$
      end if
    end for
    $T_{ik} \leftarrow T_{ik} + T_{ijk}$
  end for
end for
for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
  $TopicCount_k \leftarrow TopicCount_k + T_{ik}$
end for

Algorithm 5. Number of times learners accessed specific pages on portal

INPUT: A finite set of Learners L = L_1, L_2,...., L_N Pages P =P_1, P_2,...., P_R and Sessions S =S_1,S_2,...., S_Q
OUTPUT: P_{ik} = Number of times one Learner accessed specific $Page_k$ in all sessions
$PageCount_k$ = Number of times all the Learners accessed specific $Page_k$

initialize $P_{ik} \leftarrow 0, P_{ijk} \leftarrow 0, PageCount_k \leftarrow 0$
for *each Page* P_k where $k \leftarrow 1$ **to** R **do**
  for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
    for *each Session* S_j where $j \leftarrow 1$ **to** Q **do**
      if *Page* P_k *is accessed* **then**
        $P_{ijk} \leftarrow P_{ijk} + 1$
      end if
    end for
    $P_{ik} \leftarrow P_{ik} + P_{ijk}$
  end for
end for
for *each Learner* L_i where $i \leftarrow 1$ **to** N **do**
  $PageCount_k \leftarrow PageCount_k + P_{ik}$
end for

6 Results and Discussion

1. **Analysis done from database: Total time spent on specific file by learners in all their sessions -** Fig. 2 shows that the total time spent on specific file by learners in their all sessions. Learners who have been accessed portal are spent time on files in different sessions. The graph is showing the result of most frequently accessed files by learners in specified duration.
2. **Snapshot of report at instructor side: Number of times a specific type of file accessed by learners -** Fig. 3 shows the report which an instructor can generate to get learner wise count of accessing different types of files. As per implementation, the portal is supporting only for PDF, PPT and Video files. Depending on frequency of accessing specific types of file, learners interest in specific material can be identified.
3. **Analysis done from database: Number of times learners accessed different topics -** Fig. 4 shows the number of times learners accessed the topics with the material. This analysis will give the interest in specific topic and requirement of providing good material on different topics. The analysis can be further captured

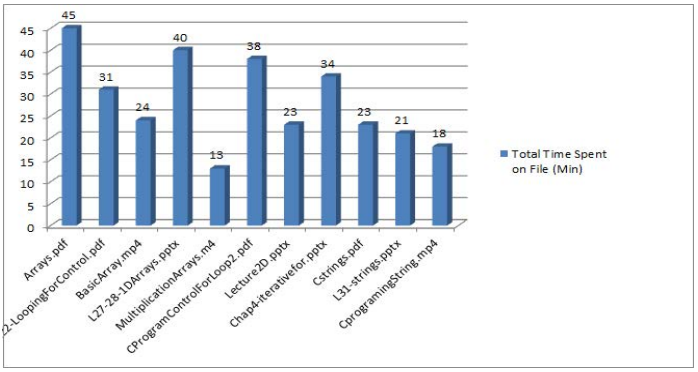

Fig. 2. Time spent on specific file by learners

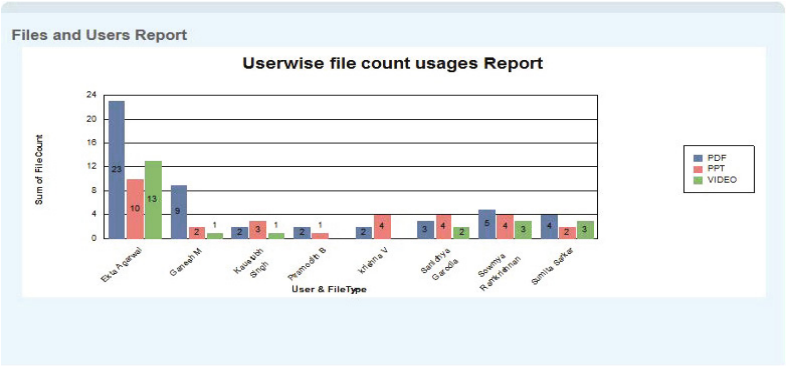

Fig. 3. Number of times Learners accessed specific type of file

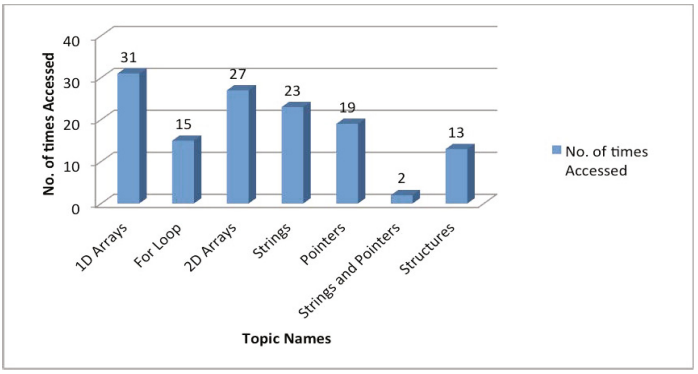

Fig. 4. Analysis of Number of times Learners Accessed Different Topics

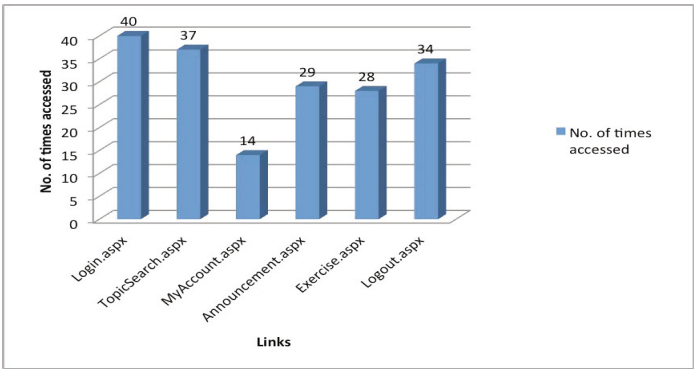

Fig. 5. Analysis of number of times learners accessed different pages

into accessing the topics as per learner's requirement, e.g., how many learners accessed previous concept or advanced concept topic after accessing main topic.

4. **Analysis done from W3C log files: Number of times learners accessed different pages on portal -** Fig. 5 shows that learners have not only accessed TopicSearch to access different files but also accessed other pages such as exercise and announcement pages. This analysis is important to understand the behavior of learner's on portal.

7 Conclusion

Online courses learning cannot be complete without incorporating the learning styles of the learners in e-learning portal which leads to adaptive e-learning approach. In this context, one challenge is to develop a portal which will be able to the identify learning styles of learners and change the user interface components as per learner's requirement.

In the proposed work, the prototype version of e-learning portal has been developed to capture the usage data of learners through log files and database. The initial level of analysis with respect to time spent on different types of files and number of times files accessed is done.

Our method of capturing the learning styles comprises not only IIS log files but also database entries where important factors of learning styles are captured. The usage data is useful to identify the learning styles of the learners and classify the according to FSLSM four dimensions such as Preprocessing, Perception, Input and Understanding and eight categories of mentioned dimensions like Active/Reflective, Sensing/Intuitive, Visual/Verbal and Sequential/Global.

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