

PERSONALIZED E-LEARNING SYSTEMS: A USER MODELING TECHNIQUE

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ABSTRACT: For providing the personalization feature to e-learning systems, a Human Computer Interaction HCI technique, User Modeling was considered in system design. This study was undertaken to propose a technique to model the students' learning styles for personalized e-learning system. Bayesian Network BN was used to model the students' learning styles and Kolb's learning styles theory was used to know the students' learning styles and preferences. The objective of the study was to propose a user modeling technique for personalized e-learning systems to understand the e-learners' requirements and needs to enhance their learning. Using BN, Conditional Probability Tables CPTs were determined for all four learning styles provided by Kolb's theory. The threshold values were used to determine the learning styles of students during an online course. We found that BN technique determined successful as from the Divergers 100%, 75% Assimilator, 50% Accommodators and 75% Convergences were identified accurately.

Key words: Personalized e-learning systems, User Modeling, Bayesian Network, Learning Styles.

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INTRODUCTION

User Modeling is an essential part of intelligent systems design. Personalized e-learning systems are the intelligent systems which can be characterized as Adaptive Hypermedia Education Systems AHES and Intelligent Tutoring Systems ITS. The AHES have an essential characteristic of adaptivity as per the students' model (Brusilovsky and Millán 2007). User Modeling is a technique to represent the original users of the system. The AHES can adapt the learning contents and other activities for e-learners as per their user models. For user modeling, the data can be gathered either from observing the users' behavior or from filling the forms directly from the users. This data is used to model and classify the users to facilitate them accordingly (Brusilovsky 1998; Brusilovsky 2007; Brusilovsky and Millán 2007). Many past studies, i.e., (Brusilovsky and Millán 2007; Schiaffino, Garcia *et al.* 2008; Özpölat and Akar 2009; Yang, Hwang *et al.* 2013; Truong 2016) have mentioned the use of learning styles to model the students for personalized e-learning systems. Many user model techniques have been used to model the students, i.e., Profiles in ITS by (Schiaffino, Garcia *et al.* 2008), Students' knowledge level by (Boyle and Encarnacion 1998), Learning styles by (Weber and Specht 1997; Graf 2007). Past research studies have used Felder Silverman's learning style theory (Felder and Silverman 1988) to adopt the learning styles for personalized e-learning systems, because this learning style theory is easy to be incorporated to understand students' learning styles on learning management system (Graf 2007). However, some research studies, i.e., (Derntl and Graf

2009; Siraj 2012) have reported unsatisfactory results of personalized e-learning systems in which Felder Silverman's learning style theory was adopted. Therefore, Kolb's learning styles model (Kolb 1984) is used during present study to understand the students' learning styles on learning management system. This study is using probabilistic technique Bayesian Network (Jensen 1996) to model the students / e-learners according to the Kolb's learning style theory (Kolb 1984)

MATERIALS AND METHODS

Data Collection: When one wants to model the user, it is required to collect huge data about the user. For modeling students of e-learning system using learning styles, it is required to map the students' behavior on learning management system with his/her learning style. Therefore, a survey of more than 800 students (e-learners) was conducted to understand and map their behavior with their learning styles. The students' survey data provided us information about e-learner's learning styles and their activities on learning management system, i.e.,

- Login time for attending online lecture
 - E-learners' Material reading behavior
 - Assignments/Quizzes submission behavior.
 - Preferred contact person during course learning.
- The next step was to model the students' behavior as variables using BN.

E-learners' Modeling using Bayesian Network: For e-learners' modeling BN was used. The basic equation of Bayesian Network BN was used, mentioned as Eq.1.

$$p(Cj | d) = \frac{p(d | Cj)p(Cj)}{p(d)} \quad \text{Eq.1}$$

Where

$p(Cj | d)$ = probability of occurrence d in class Cj

$p(Cj)$ = probability of occurrence of class Cj

$p(d)$ = probability of case d occurring

To construct a BN for users' model, the following steps were headed:

Step1: Modeling variables and their related proportions: For the current study, the Kolb's four types of learning styles, i.e., Diverger, Assimilator, Converger and Accommodator for learners were used. Therefore the learning styles were supposed as variables and proportions as e-learners' behaviour observatory factors, i.e., login time, frequency of discussion board

participation and type of participation, course activities participation, frequency of contact with teacher and friends via collaborative activities and material downloading behaviour. The graphical representation of students' modelling with BN was shown by Figure 1.

Step2: Create the BN structure for Students' model: For creating the BN structure Eq. 2 was used for the undertaken problem.

$$P(v_1, \dots, v_n | I) = \prod_{i=1}^n P(v_i | v_1, \dots, v_{i-1}, I) \quad \text{Eq.2}$$

For every variable v_i the subset was $\prod_i$ and it defined the BN structure because of the conditional independence of V_i and $\{V_1, \dots, V_n\}$,

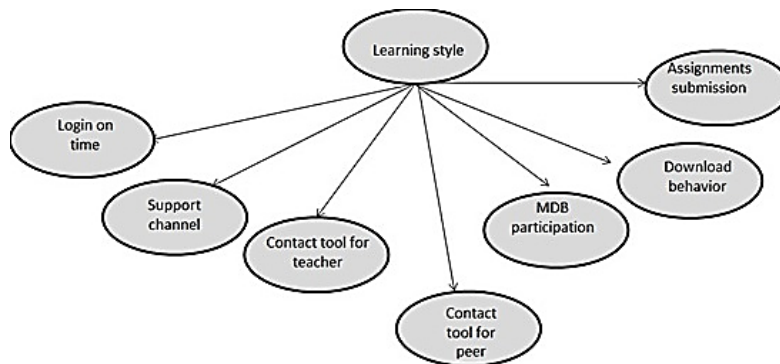


Figure 1: Graphical representation showing students' modeling with BN

The data for determining the parameters for BN were collected from the online students' survey of Virtual university VU of Pakistan .More than 800 online students who were registered in different courses were surveyed to ask about their behaviour on learning management system. The learning styles of the participants were first known by an online survey using standard questionnaire of identifying Kolb's learning styles manually. This data

was pre-processed and then processed using BN to acquire probability values for each learning style. The probability values were constantly be updated when the system updated with new frequencies of considered factors. Resultantly the Conditional Probability Tables CPT were acquired for each attribute considered.The CPT for students' contact person was graphically represented using Figure 2.

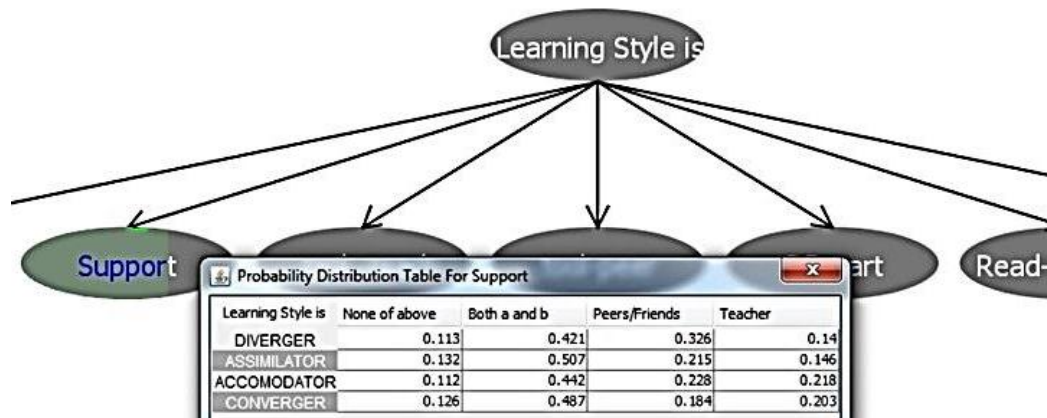


Figure 2: Showing the CPT for students' preferred support channel

RESULTS AND DISCUSSIONS

The e-learners' behaviour was analysed and classified. Different CPTs were determined for each

behavioural factor to classify all four learning styles. The CPT for all four types of students on an e-learning system were shown using Table 1.

Table 1. The Probability values (CPT) for All Four Kolb's Learning Styles on e-learning system

Diverger	Assimilator	Accommodator	Converger
0.373	0.082	0.23	0.315

The acquired probability values were evaluated with 20 students of a public University of Pakistan using Software Engineering online course. Moodle was used for this experiment as the Learning Management System LMS; students' behaviour was observed and averaged with already mentioned probabilities. The results of mentioned students' modelling approach were shown by Table 2 and also by figure 3. First, all four learning styles were detected using Kolb's standard questionnaire Kolb's learning Style Inventory KLSI (Kolb 2005) and then the same students' behaviour was averaged from the record of log files.

Table 2. The Student type detection using BN and KLSI

Student Type	BN Identification	KLSI Detection
Div	3	3
Ass	3	4
Acc	2	4
Con	3	4

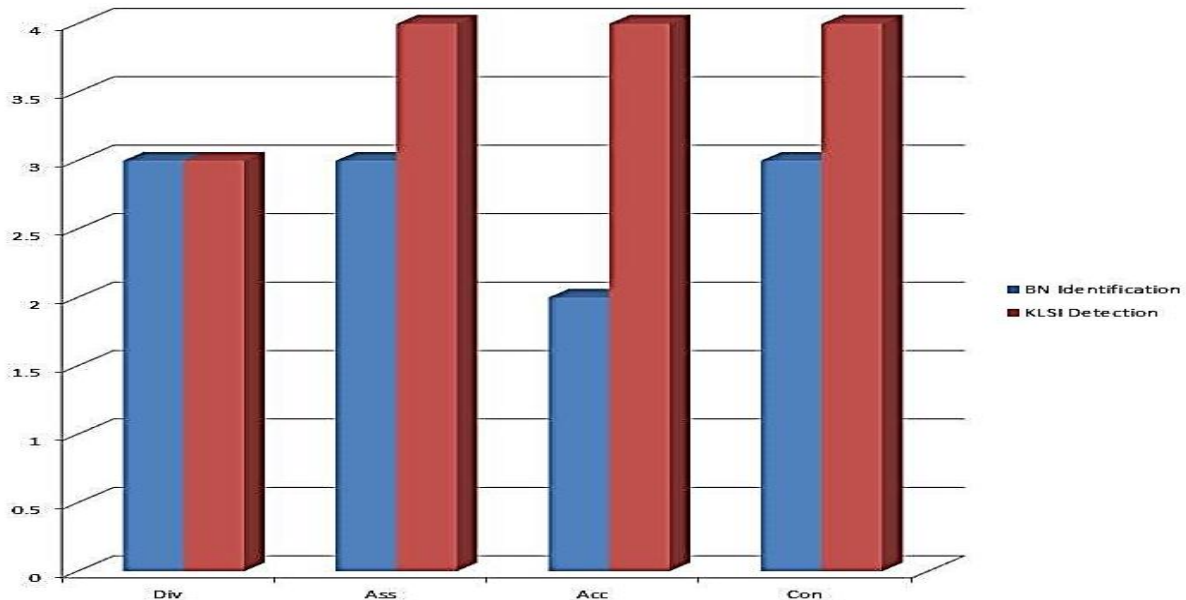


Figure 3. is showing the results acquired by BN

The present study proposed a probabilistic model for e-learners' modelling on personalized e-learning systems. We found that BN technique determined successful as from the Divergers 100%, 75% Assimilator, 50% Accommodators and 75% Convergers were identified accurate. However, in past studies, i.e., (Paredes and Rodriguez 2004) used a mixed approach for e-learners' modelling. The students had to first fill the form to know about their learning styles and then the

system could recognise automatically.(Cha, Kim *et al.* 2006) used decision tree DT and achieved results by obtaining an error rate of 0% for Felder Silverman's Learning styles (Felder and Brent 2005). (García, Amandi *et al.* 2007) used BN for detecting Felder Silverman's Learning styles (Felder and Brent 2005). They achieved 77% for sensing/intuitive, 58% for active/reflective and 63% for sequential/global students. (Graf, Viola *et al.* 2007; Graf, Kinshuk *et al.* 2009) used

literature based approach for students' types detection and used BN for students' modeling and the average results were between 73% to 79%. Also (Ahmad, Tasir *et al.* 2013) found 75% accuracy in their experiment. (Atman, Inceoglu *et al.* 2009) identified 83% and 79% accuracy in two experiments. However, all the studies used Felder Silverman's learning style theory (Felder and Brent 2005). Keeping in view the mixed results of various studies, the present study proposed user modelling technique for modelling the Kolb's learning style theory (Kolb 2005) which is found satisfactory in class room teaching. Moreover, the present study proposed threshold values for automatic classification of e-learners while they come into contact with web educational system.

Conclusion: The present study proposed BN technique for e-learners' modelling using Kolb's learning style theory (Kolb 1984). Using BN CPTs are determined for all four learning styles. The threshold values can be used to identify all four above mentioned learning styles on personalized e-learning system. When the e-learners will interact with learning management system, the students' learning styles can be automatically using the determined threshold values. The learning styles' detection assist e-teacher to teach the students according to their learning style and ultimately the learning of e-learners will be enhanced.

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