



# A Hybrid Approach to Classify the Learning Style of Learners in an E-Learning Environment

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## ABSTRACT

*Learning style identification has a significant role in the process of setting a personalized learning environment and for providing adaptive courses. It helps the students to understand their strengths and weaknesses when it comes to learning and subsequently helping them by improving their learning outcome, increasing satisfaction, and reducing the time needed to learn. Hence, the objective of the study is to develop a method to identify the learning style of learners based on Felder-Silverman Learning Style Model for achieving an adaptive learning environment. In this study a hybrid learning style classification mechanism is proposed by incorporating K-NN classification approach with a computational intelligence algorithm to identify the learning style of learners in an online learning environment. A Moodle log data will be used to evaluate the performance of the proposed algorithm.*

**Keywords:** *Computational Intelligence algorithm, Felder-Silverman learning style model, K-NN classification, Hybrid learning style classification, Moodle log data*

## 1. Introduction

Nowadays, Information and Communication Technology (ICT) has pervaded the fields of education and term “e-learning” has emerged as a new alternative to the traditional learning system. Since learners in an e-learning environment have individual differences and prefer different ways of learning, there is a big challenge for 21<sup>st</sup> teachers to provide suitable learning materials according to the interest of these learners. With the growing demand in e-learning, numerous research works have been done to enhance teaching quality in e-learning environments. Among these studies, researchers have indicated that adaptive learning is a critical requirement for promoting the learning performance of students. Learning styles can be considered as one such factor for providing a suitable learning content or organizing these contents in LMS. Identifying students’ learning styles has several benefits such as making students aware of their strengths and weaknesses when it comes to learning



and the possibility to personalize their learning environment according to their learning styles. Hence this study proposes a method to identify the learning style of learners using an efficient classification algorithm. In this method a novel approach is introduced, which combines the advantages of computational intelligence and KNN-classification approach. A Moodle log data will be used to evaluate the performance of the proposed algorithm.

The structure of the paper is organized as follows. Section I explains about the importance of identifying a suitable learning style mechanism. Section II surveys some related works in this area. Section III explains the proposed approach and the methodology used for identifying the learning style. Section IV concludes the study with some evaluation methods.

## **2. Related Works**

This section provides some background information regarding the importance of identifying students' learning styles and explains few existing approaches used for identifying the learning styles automatically.

In a traditional class room environment teachers can easily understand the way in which students behave and learn. But it is difficult to know how learners in an e-learning environment learn and behave. Hence in order to provide students with an enhanced learning environment many factors have to be considered. Adaptation system is the central component of any e-learning system and is responsible for tailoring learning materials or contents according to the learners' style, profile, interest, previous knowledge level, goal, pedagogical method etc to provide highly personalized learning sessions [1]. Based on various studies it is found that learning styles have been gaining significant interest from researchers and educators [2]. Many literature surveys showed that learning style is an indicator of how a student learns and likes to learn, and how an instructor teaches to successfully address the needs of the individual students. Students acquire and process information based on their learning styles [3]. A learning style construct is a valuable description that helps students to understand how their learning process works. Knowledge about student's learning style is important because it allows educational practitioners and instructional designers to adapt their teaching styles and educational material according to their students' learning styles [4]. It also helps to improve their learning performance, enhance motivation, increase enjoyment, and reduce the learning time. According to Graf and Liu (2009) there exist several learning style models and they have used the Felder–Silverman Learning Style Model (FSLSM) [3]. Because it has been widely applied in engineering education and research related to learning technologies [5]. This model has four dimensions and two categories in each dimension. They are (a) Active and Reflexive (A/R) (b) Sensitive and Intuitive (S/I) (c) Visual and Verbal (V/V) (d) Sequential and Global Learning Style (S/G).

Two commonly used approaches for identifying the learning style of students are collaborative approach and automatic approach. In collaborative approach learning style is determined using a questionnaire called Index of Learning Style, (ILS). But the automatic approach contains two methods: Data-driven method and Literature-based method. The data-driven method aims to build a model that imitates the ILS questionnaire and uses



sample data to construct a model. In this method various techniques like Bayesian networks, decision trees, Hidden Markov model, Fuzzy clustering, are used to construct a model from the existing behaviour data. Subsequently student behaviour data is used as input to this model for identifying the learning style. In literature-based method, the behaviour of students is used to get hints about their learning style preferences. Instead of building a model, this method uses simple rule-based approach to calculate learning style from the number of matching hints.

Literature-based method is used for identifying learning styles based on relevant behaviour features obtained while using a Learning Management System [6]. Since this study uses FSLSM, the characteristics and behaviour patterns refers to the dimensions found in this model. The features relevant to FSLSM are course outline, content objects, exercise, assessment and forums.

Despite the fact that there exist learning style questionnaires for identifying a student's learning style, such questionnaires have several disadvantages. Therefore, many researches have been conducted on automatically identifying learning styles from students' behaviour in a learning environment [7]. Automatic detection of learning styles of online learners is an important requirement for personalized e-learning [8]. Advantages of providing a personalized learning content to such learners is that it improves their learning outcome, increasing satisfaction, and reducing the time needed to learn [9].

There are many existing approaches for identifying the learning styles automatically. A comparison table of various methods used to identify learning styles are explained in Table 1. According to Graf (2007), the automatic method for learning style identification can be either a data-driven or literature-based approach [10]. In order to identify learning styles, student behaviour data related to different types of learning objects (e.g., content, quizzes, forums, etc.) can also be used [11]. In this study they have used rule-based algorithm and found that this method can be applied for any learning systems in general. After the evaluation, the precision of the learning style identified was 79% for A/R, 77% for S/I, 77% for V/V and 73% for S/G. A study made by García (2007) used a Bayesian network, but they couldn't identify V/V dimension [12].

According to Felder & Silverman (1988), different learning styles may lead to different abilities to solve problems [3]. Data about students' behaviour can be used as hints for learning style preferences depending on Fielder Silverman Learning Styles Model (FSLSM). Hence determining the patterns that provide hints to identify students' learning styles in an online learning environment is important. All these researches were used only for identifying students' learning style. However, the approach to classify students dynamically depending on their learning style and the lack of validation of the classification process has to be considered [14].

Identification of students' learning style is considered as the first step for providing adaptive learning materials and proposed a learning style classification mechanism to classify and then identify students' learning styles [15]. This paper used k-nearest neighbour (k-NN) classification and proposed a mechanism to improve k-NN classification and combined it with genetic algorithm.

Regarding the precision at identifying learning styles, an evaluation result on the current approaches showed an average precision between 66% and 77%. It points out the need for improving such automatic approaches



before using effectively in learning environments. The use of computational intelligence (CI) algorithms helps to improve the precision of automatic approaches in identifying the learning styles [7]. In this study authors proposed the use of artificial neural network (ANN) for identifying learning styles and evaluated the use of three optimization algorithms genetic algorithm, ant colony system and particle swarm optimization with respect to their potential to improve the precision of automatic learning style identification. They considered these algorithms as a classification problem as well as an optimization problem.

Many studies showed that k-NN is one of the most popular classification techniques. According to [15], the use of genetic algorithm helped to extract a large number of learning behavioural features. In their study they introduced a new algorithm called 'Pre-Contrast algorithm' which addressed the issue of computation complexity. It helped to reduce the time for computing distance between an unclassified data and samples. A currently leading approach for detecting the learning styles, DeLeS, considered each behaviour pattern in the calculation of learning style [11]. But the study [7] investigated, how the use of CI algorithms can improve existing literature-based method for identifying learning styles as a classification problem as well as an optimization problem.

Table 1. A comparison table of various methods

Study	Methods	Purpose
(Ahmad, N., Tasir, Z., Kasim, J., & Sahat, H. (2013)	Literature-based method	Identify learning styles based on behaviour
García, P., Amandi, A., Schiaffino, S., & Campo, M. (2007)	Bayesian network	Identify learning styles
Graf, S., & Liu, T. C. (2009)	Rule-based	Used student behaviour data related to different types of learning objects to detect learning style
Graf, S., Lan, C. H., & Liu, T. C. (2009, July)	Rule-based	Considered the behaviour patterns to detect learning style
(Chang, Y. C., Kao, W. Y., Chu, C. P., & Chiu, C. H. (2009)	Enhanced K-NN and Genetic algorithm	To extract a large number of learning behavioural features for learning style classification
(Bernard, J., Chang, T. W., Popescu, E., & Graf, S., 2017)	Computational Intelligence algorithm	Improve the precision of automatic approaches in identifying the learning styles

### 3. Proposed Approach

Based on the above mentioned literature surveys, it is found that there are many existing researches for identifying students' learning style. However, the approach to classify students dynamically depending on their



learning style and the lack of validation of the classification process are some important factors need to be addressed[14]. CI algorithms are capable of handling these issues by considering the behaviour pattern of each learners, in an appropriate way [7].Based on these factors, the proposed study suggests a hybrid learning style classification mechanism by incorporating K-NN classification approach with one computational intelligence algorithm. Fig 1 shows a frame work of the proposedwork.

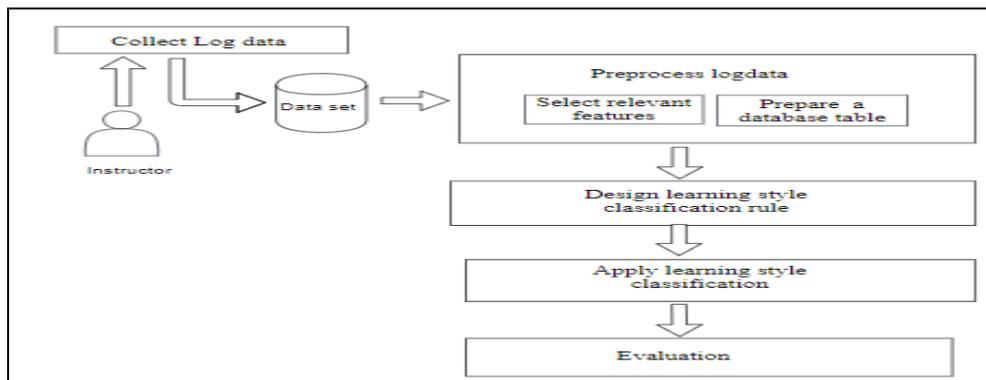


Fig. 1. The proposed frame work

### 3.1 Methodology

Various steps involved in the proposed method and its evaluation procedures are explained in the following section.

#### Step 1: Identify relevant dataset

A Moodle data set will be used for the evaluation of the classification criteria.

#### Step 2: Preprocess action logs

Here the dataset is to be prepared for performing classification. Initially a preprocessing of the data has to be performed; it is the process of organizing student’s behavior data, based on the log data obtained to prepare the dataset suitable for performing classification. Following are the processes involved in achieving it.

(a) Choose appropriate features that matches FSLM dimension from the dataset identified. A sample screenshot obtained from[13]is shown in Fig. 2.

Relevant pattern for active and reflective learning style (The “+” and “-” indicate a high and low occurrence of pattern)	
Active	Reflective
content_visit (-)	content_visit (+)
content_stay (-)	content_stay (+)
exercise_visit (+)	exercise_visit(-)
exercise_stay (+)	exercise_stay (-)
example_stay (-)	example_stay (+)
outline_stay (+)	outline_stay (+)
forum_visit (+)	forum_visit (-)
forum_post (+)	forum_post (-)
forum_stay (-)	forum_stay (+)

Fig. 2. Sample Screen shot



(b) Prepare a database table consisting of these features to represent them in an appropriate format to create behaviour classification rule.

*Step 3: Rule estimation process*

In this step a learning style classification rule has to be designed, based on student's behaviour features identified. It helps to identify the learning style of students using the identified features. A sample output is explained in Table 2.

Table 2.A sample output

Student-id	Active/Reflective	Sensitive/Intuitive
1	17	20
2	10	11
3	0	1

*Step 4: Classification*

In this step students are classified to their learning style using the proposed algorithm.

*Step 5: Evaluation*

The precision of the learning style identified will be calculated during the evaluation of the classification result.

#### 4. Conclusion

This work has presented an overview on various existing learning style classification mechanisms. The effectiveness of implementing a hybrid algorithm for identifying the learning style of students based on their behaviour features in an online environment is also discussed in this study.

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