

# *Decision Support System for Learning Disabilities Children in Detecting Visual-Auditory-Kinesthetic Learning Style*

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**Abstract**—The innovation of information and communications technology in education has improved the learning quality and has provided a positive impact on the learning environment and its community. Integrating learning styles in adaptive e-Learning systems has been considered a growing trend in technology to improve the learning process. Also, when these technologies are obtainable, reasonable and available, they represent more than a transformation for people with disabilities. The purpose of this research is to adopt a decision support system in e-learning in order to model the visual-auditory-kinesthetic learning style focusing on learning disabilities children. Learning disabilities children face difficulties in processing and retaining information and thus have problems in the classroom. Providing adaptively based on learning styles has potential to make learning easier for students and increase learning progress. The traditional way to identify learning styles is by using questionnaires. Even though, the problem with the traditional approach is not all the students are interested to fill out a questionnaire. Hence the most recent years, several approaches have been proposed for automatically detecting learning styles to solve these problems. Therefore, the main aim of this paper is to propose e-learning decision support system architecture to estimate students' learning style automatically using literature-based method. Calculation to estimate each of the student's learning styles based on number of visits and the time that spent on learning objects with respect to the visual-auditory-kinesthetic learning style.

**Keywords**—learning disabilities; decision support system; visual-auditory-kinesthetic learning style

## I. INTRODUCTION

Today Information and Communication Technologies (ICT) have been broadly applied to the field of education and learning technologies transformed educational systems with impressive progress. The enhanced use of ICT in most sectors of the community, especially in supporting education and inclusion for persons with disabilities can be a powerful tool to improve their quality of life. Many children with disabilities are facing a wide range of barriers, including omitted from educational opportunities and do not complete primary education [1]. The effective application of technologies can ensure comprehensive classroom learning, accessibility, teaching and learning content and techniques more in friendly with learners' needs. E-Learning appears as a new education paradigm to fulfill that learners need, overcome physical deficiency of the users and decrease barriers in education [1, 2, 3]. Some researchers have explored that accommodating learning styles-based approach in e-learning has proven to be effective in the classroom and allows individual learning styles and preferences to be accommodated [3, 4, 5]. Students with learning disabilities may have different learning difficulties from each other [3] and have different ways in their own

learning processes to help them learn better. These several well-known learning style models such as Kolb, Honey & Mumford, Dunn & Dunn and Felder-Silverman. To implement the adaptation in such e-Learning systems, students' learning styles need to be identified first.

There are many ways of identifying learners' learning style and commonly it is static approach that uses a questionnaire. This approach is still useful until now. But, the problem with the questionnaire approach is not all the students are interested to fill out the questionnaire and the result depends heavily on students' mood [6]. Moreover, these questionnaires are unable to detect changes in a learner's learning style [7]. As a result of these problems, various researches have been concentrated on how to identify learners' learning styles automatically. There are two broadly approaches, including data-driven approach (DDA) and literature-based approach (LBA). Generally, the idea of the automatic detection learning style can be simplified as Fig. 1. In our study, we choose the literature-based approach to automatically detect learning styles of learners in DSS e-Learning systems. In this research, we propose approach decision support systems for specific groups of users, by taking into consideration user's learning style in e-learning.

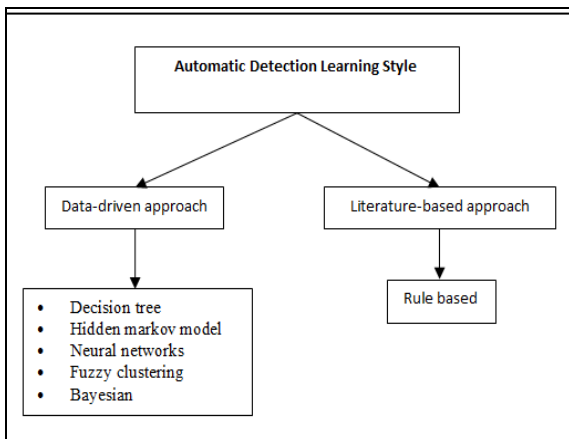


Fig. 1. Idea of automatic detection learning style

## II. DECISION SUPPORT SYSTEM

A decision support system (DSS) is an interactive computer-based system capable of supporting decision-making process. Lately, DSS technology has been positively applied to many decision-making problems in numerous disciplines, including education [8]. DSS as part of e-learning systems can analyze data in users' profiles and allow the learners to select optimized learning paths based on previous learning information about learners [9]. Individuals with learning disabilities possibly will have dissimilar problems from each other. Therefore, it is supposed that learning surroundings which are developed for learning disability individual should be adapted to the learning need of the individual. DSS is suitable and has many advantages for education of learning disability students as they can deliver a different presentation of learning contents and recommends adaptive learning paths based on analyses previous learning activities [3, 8]. The DSS in our approach systems can be described as the systems that determine the students' learning styles automatically and delivers a different presentation of learning content for learner's with different learning styles.

## III. LEARNING DISABILITIES CHILDREN

The learning disability is an umbrella term that describes of learning problems includes dyscalculia, dysgraphia, dyspraxia, central auditory processing disorder, non-verbal learning disorder, visual-spatial disorder, visual motor disorder, developmental aphasia and language disorders [10] such figured in Fig. 2.

The Malaysian Ministry of Education categorized learning disabilities students under special needs [11]. The Ministry of Education offers special education programs for hearing, visual and learning disabilities students [12]. Learning disabilities child differ from each other and may not have the same learning problems as another child with LD. Most of these children face a wide range of problems in educational chances

and not completed primary education [1]. There is no treatment for learning disabilities, but they can be high achievers and learn successfully with the right help [1, 13].

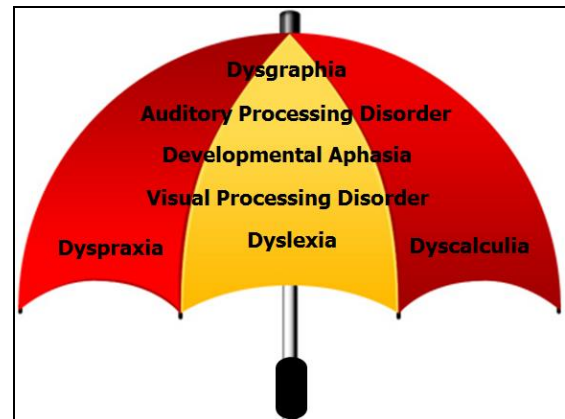


Fig. 2. Learning disabilities

Numerous researches have shown that emerging learning environments blended with technology can play an important role in specific disadvantaged groups such as the blind, those with movement disabilities and LD. It also gives a great potential to support and enhance students learning processes to live freely and learn easier [3, 14, 15]. It is a good transformation and opportunity for the LD people solve the problems that happen in traditional educational systems. Traditional computer learning environments proposes the same content and they do not consider the individual differences, preferences and interests [3].

## IV. LEARNING STYLE

According to Keefe, define learning styles as 'cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to learning environments'. By identifying student's learning style, teachers should be encouraged and provide to create a learning process sensitive with the students' learning needs [16, 17]. Learning styles are significant in the learning process since they may help student's achievement is improved and would be to increase self-awareness of the strengths and weaknesses [18, 19, 20].

There are numerous models of learning styles from the literature, like Felder- Silverman, Dunn and Dunn, Honey and Mumford, Kolb and Visual- Auditory-Kinesthetic (VAK) learning style model [21]. VAK and Felder are two well-known models used in adaptive e-learning system [20]. The main purpose for selecting a VAK learning style of our work that this learning style is most widely-used, simple, suitable for children and identify a student's dominant mode of perceiving information [22, 23, 24]. Fig.3 shows the features VAK learning style model.



Fig. 3. VAK learning style

The VAK learning style model focuses on human observation channel vision, hearing and feeling. This model is categorizations into three modalities, firstly visual learners, secondly auditory learners and lastly kinesthetic learners or tactile learners [23, 25, 26]. Visual learners prefer to learn via seeing. For these learners, pictures, flow diagrams and videos are the best learning instruments. Auditory learners have a preference for listening, audibly and learn best by hearing. Kinesthetic learners’ best learn through feeling or doing-experiencing such as moving, touching, and doing [27]. For these learners, computer games, interactive animations are the best learning instruments [21, 23]. Based on each mode’s tendency, automatic learning style detection is conducted to obtain students’ feedback on computer based learning.

## V. METHOD

Because of the limitations and disadvantages of questionnaire-based learning style detection, the detection process must be computerized. From previous studies, it is clear that the process of automatic detection of learning styles includes fundamentally two stages. The first stage is identifying the significant behaviour for each learning style and the second stage is inferring the learning style from the behavior and actions of an individual [7, 28] (see Fig. 4). Identifying the significant behaviour for each learning style involves three phases, firstly is choosing the relevant features of behaviour, secondly is categorizing the occurrence of the behaviour and last one is defining the patterns for each element of the learning style. For the identifying the significant behaviour for each learning style involves of the three phases, firstly is choosing the relevant features of behaviour, secondly is categorizing the occurrence of the behaviour and last one is defining the patterns for each element of the learning style. Then the calculation methodology can be data-driven or literature-based approach in the inferring learning style stage [29].

### A. Literature-Based

The literature-based approach is to use the behaviour of students in order to get suggestions about their learning style

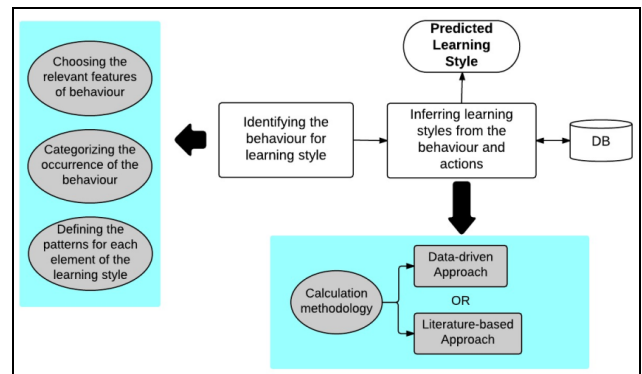


Fig. 1 Concept of automatic detection of learning style

preferences [16]. This approach was proposed by Graf et al. [30]. Then a simple rule-based method is applied to calculate learning styles from the number of matching hints. This approach is same to the technique used for calculating learning styles in the Index of Learning Styles (ILS) questionnaire and has the benefit to be nonspecific and relevant for data assembled from any course [31].

Several studies have been used in literature-based approach, such as, Graf, et al. [30], which first proposed the new methodology of literature-based approach for automatic detection of styles preferences according to the Felder-Silverman learning style model (FSLSM), in Learning Management Systems (LMS). Simsek, et al. [32] recommended a literature-based approach for automatic student modelling taking into consideration the learner interface interactions. George, et al. [7] propose to use a mix of data-driven approach and literature-based approach. Dung and Florea [33] use literature-based approach for automatic detection of learning style and use the number of visits and time that the learner spends on learning objects as parameters. Ahmad, et. al [16] use literature-based approach to analyzed pattern of behaviour for Malaysian polytechnic students who studied Interactive Multimedia course. In our approach, we use the VAK learning style model and follow literature-based approach and used a simple rule engine to estimate the learning style.

### B. Learning Styles Estimation

Literature-based method is used to estimate learning styles automatically. Calculation to estimate each of the student’s learning styles based on number of visits and the time that are spent on learning objects. Learning object can be defined as “any digital resource that can be reused to support learning” [31]. This meaning contains all that can be delivered across the network on request. Examples of digital resources include digital images or photos, live or prerecorded video or audio snippets, small bits of text, animations, smaller web-delivered applications, multiple choice exercise, and book [34].

The predictable time spent on each learning object,  $Time_{predictible}$ , is determined. The time that a learner actually spent on each learning object,  $Time_{spent}$ , is recorded. For example, if  $Time_{predictible}$  of a visual learning object is 30 second. After a period of time X, sums of  $Time_{spent}$  for three learning style elements of the learner is calculated. Then, the ratios of time (RT) are found out as the formula in eq.1.

$$RT_{LS} = \frac{\sum Time_{spent}}{\sum Time_{predictable}} \quad (1)$$

To calculate the ratio of number\_visit,  $RV_{LS\_element}$ , number of learning object visited,  $Ex_{visit}$ , and total of learning object,  $Ex$  each learning style element are compute using the formula as eq. 2.

$$RV_{LS\_element} = \frac{\sum Ex_{visit}}{\sum Ex} \quad (2)$$

Finally, the average ratios,  $R_{avg}$ , are calculated as the formula in eq. 3.

$$R_{avg} = \frac{(RT + RV)}{2} \quad (3)$$

Then learning style is estimated based on the simple rule as shown in Table 1:

TABLE I. SIMPLE RULE ESTIMATION OF LEARNING STYLES

Ravg	LS
0 – 0.3	Weak
0.3 – 0.7	Moderate
0.7 – 1	Strong

## VI. RESULTS AND DISCUSSIONS

In order to meet individual user’s needs to teaching delivery, LS models have to be established and integrated within e-learning. The review as showed in this study the significant role that reliable learning style models can play in enhancing the learning ability and learning background if these are well-matched. Numerous past studies have shown that the VAK learning style model which represents one of the commonly used, very simple and suitable for children [22, 23, 24 ,27]. Previous study presented that automatic approach as a better approach to identify learning style in online learning because it is based on the actual students’ behaviour pattern while learning [35]. The purpose of this research, literature-based approach is chosen. This approach use rule based method for identifying learning style. According to Graf [29], the main strength of literature-based approach is the ability of deducing LS without needing training data and depends directly on learning style model. We construct our own research architecture DSS e-learning for LD children and to be used conveniently in the future.

### A. Research Architecture

In this section, we comprehensively describe the architecture of DSS e-learning for LD children and demonstrate the individual components needed to implement our approach. The proposed architecture is represented in Fig.

6. The structure of the system consists of user interface, adaptive engine, content service, system manager and personal profile service. The user interface deals with the learners’ registration and this service is responsible for user login. The service will add information in profile model database and communicate with the learners’ personal profile service agent, The Adaptive Engine (AE), is responsible for suggesting the learning styles according to learners behaviours. Content Service control what type of learning materials should be provided to each learner based on their learning styles. System Manager allows the teachers to update the content. The personal profile service saves the users’ information from the profile model database and communicate with the adaptive engine in order to decide to deliver the right learning materials

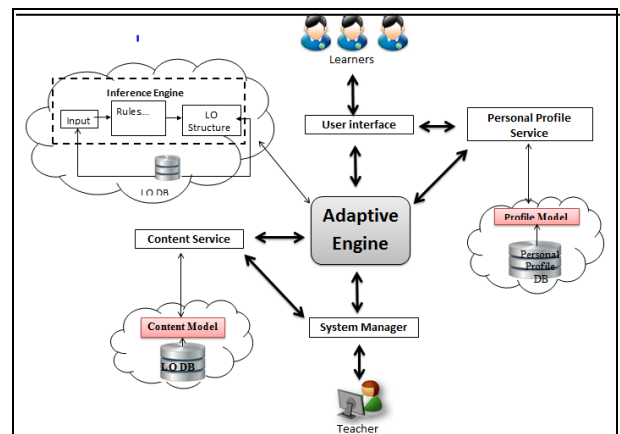


Fig. 2. The architecture of the System

## VII. CONCLUSION

The main conclusion of the present study is that the future research should take into account that LD students need to be encouraged to learn something they like. Based on that, we will design a DSS e-learning system that adapts to learners’ preference of learning style automatically. We propose an e-learning DSS system architecture to detect the students’ learning styles automatically using a literature-based method. This method is based on the rule base for calculating to estimate each of the student’s learning styles based on number of visits and the time that he or she spent on learning objects. Our future work will concentrate on extensive development in validating the proposed system and the efficiency of the method.

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