A NEW APPROACH FOR IDENTIFYING LEARNING STYLES BASED
ON COMPUTERIZED ADAPTIVE TESTING

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Abstract

Learning style has an important impact on the learning process because it puts the focus on the most effective personal mode of study more affective for each learner. In the literature, there is different representations and approaches for identification of learning styles, which implementation is complicated in computing environments for human learning. In this perspective, this article proposes a new approach to identify the learning style using adaptive testing. This approach has the potential to be implemented and give results at the beginning of online training.

Keywords: Learning Style; Educational Technology; Personalized learning; Computerized Adaptive Testing; Learner Profile.

1 INTRODUCTION

E-learning has always benefited from advances in Information and Communication Technologies (ICT) to provide relevant, well-represented content which meet learner's needs. Recent advances in Educational technology changed drastically the way we teach and learn and lead to new educational approaches overcoming the traditional obstacles of time and space. Although educational technology facilitated access to information, still moving from traditional educational settings to modern one is not as easy as it seems. Students often lack of motivation and engagement and do not get enough support throughout the learning process. Indeed, One of the on-going issues regarding today's educational technology is supporting learners in the way they learn. For instance, learners have different backgrounds, knowledge and goals; they proceed according to their own pace and might be interested in different contents at different stages of the learning process.

In order to create an effective learning experience, several researches point out the importance of the learner profile in the design of e-learning platforms. It contains all relevant characteristics about the learner. For instance, learning outcomes, knowledge level and learning style. The aim of learner profile is to gather data about students and then provide each one with a personalized learning experience taking into account his learning preferences. This has the potential to activate his interest and increase his motivation. In this contribution, we focus on learning style: a set of cognitive constructs which is about how do learners behave and react in a specific learning environment.

Identifying learning style is incredibly beneficial for all actors in the teaching learning process. For educators, it helps them be aware of the learners' predisposition to adopt a particular learning orientation. As result, they can provide each learner with appropriate resources. For students, identifying their own learning style might get them involved, and could help them recognize their strengths to succeed in their educational experiences.

The aim of this article is to present a new approach for identifying learning styles using adaptive testing. In particular, we explain the contribution of adaptive testing in education, and highlighting their potential to identify learning style at the beginning of an online training.

The remainder of this paper is structured as follows. Section 1 presents research problem. Section 2 provides background on learning styles and enumerates related approaches used to identify learning styles. Section 3 synthesizes the present study by proposing a new approach that will be used both to evaluate the prerequisites and also to identify learning styles.

2 RESEARCH PROBLEM

The study of related researches on identifying learning styles reveals two distinct approaches that could be classified into implicit and explicit approaches. In one hand, the purpose of explicit approaches is to determine the learning style by providing student with a questionnaire to fill. This later
includes general and direct questions, which detect the learner learning style. However, this test has some limitations: the questionnaire takes away the learner from the learning subject that he wants to study; and often lead to misunderstanding and misidentifying the learning style because learners are not always aware of their own learning style. In addition, they could answer in a random way in order to skip the questionnaire. In the other hand, implicit approaches propose to analyze learner’s traces to determine their learning style. They use intelligent algorithms, such us neural networks, genetic algorithms, and ant colonies algorithms that rely on machine learning techniques to generate relevant information about the learner. The results are much more effective than the traditional methods of identifying the learning style but it has notable drawbacks: at the beginning of online learning activity, learn profile hold a little information about the learners, a common problem known as e-learning cold start problem. Therefore, those algorithms need existing data to generate efficient results.

In this context, Identifying learning style at the beginning of an online training is still complicated. Choosing between (1) the efficiency of intelligent algorithms, or (2) the speed of questionnaires would be difficult, since the reliability and speed of identification of the learning style are complementary. To this end, this paper proposes a new approach to identify learning styles according to the following hypothesis: in order to personalize learning, a diagnostic test is administrated to the learner at the beginning of an online training. The goal is two-fold: from one side evaluate his prerequisites, and from the other to identify his learning style.

This article presents a new direction to identify the learning style using an online diagnostic test. More specifically, we suggest using Computerized Adaptive Testing: an adaptive questionnaire that collects information about learner knowledge level and learning style. Still, one question remains to be answered: how could Computerized Adaptive Testing identify learning style?

The next section provides some background information on learning models styles as well as related works on existing approaches for identifying learning styles.

3 LEARNING STYLE

Individual learner has his personal manner in which he requires the knowledge. For example some students prefer auditory courses while others feel more comfortable with visual or kinesthetic resources. Another example is that some students prefer to learn by doing experiences while others tend to think and reflect about it. Learning styles don’t explain just how student learn, but rather describe all student preferences for how learning material is presented, how they process information and how they retain effectively the information. The learning style has been approached by several researchers and is defined in distinct forms leading to the same end: learning centered on learner. This section presents the more popular learning style models and different approaches for identifying learning styles in the literature.

3.1 Learning Style Models

In the literature, the Learning Style Inventory (LSI) is used to identify a student's learning style. Three basic inventory types have been defined: (1) Cognitive inventories, (2) Emotional inventories, (3) Psychomotor inventories. Cognitive inventories show how the learner acquires knowledge visually, auditory or in a kinestheic. Emotional inventories are based on the learner inner behavior such as motivation, attitudes, and handling of failure and success. Finally, psychomotor inventories study the types and presentation of content preferred by learners. The more popular learning styles in the literature are introduced here.

3.1.1 Witkin 1962

This model identifies two groups of students the independent and the dependent learners. Independent learners are more autonomous. They learn with internal objectives, intrinsic motivation and self-directed goals; they are not impacted by external factors and have their own learning method. On the opposite, dependent learners are operating with external factors and extrinsic motivation, so they cannot learn without structures and assistance from the teacher. They learn effectively working in group.

3.1.2 Felder-Silverman learning styles model (FSLSM) (1988)

FSLSM consists of the four basic dimensions: active / reflective (A/R), sensing / intuitive (S/I), visual / verbal (V/V) and sequential / global (S/G). The A/R dimension explains how students gather
information. Active students prefer learn by doing experimentation and working in group, while reflective students tend to think and absorb the information alone or in small groups. The S/I component describes how students prefer to retain information. Students with a sensing preference are operating using their senses. Students with an intuitive learning style learn by exploiting their intuition and their imagination. The V/V dimension distinguishes two categories of students. Visual students tend to learn from graphs, charts or videos, while verbal students prefer words written or spoken. The last one S/G dimension is about presentation of information. Sequential students prefer information to be organized in a linear way and tend to learn progressively. On the opposite global students tend to move from non-understanding to understanding rapidly and prefer to know the main idea before seeing details.

3.1.3 Honey-Mumford Model of Learning Style

This model is based on Kolb model. It distinguishes four basic dimensions: activists, reflectors, theorists, pragmatists. Activists tend to learn by doing: They involve themselves in experiences. Reflectors prefer learning by observing and thinking: They like tend to be cautious and thoughtful. Theorists like to understand the theory before they act: They look for models, concepts and facts in order to learn. They like to analyze and synthesize. Pragmatists are more realistic: They tend to make the link obvious between the topic and a current need. They look for expert’s ideas that can be applied to the problem in hand. They like to get on with things and tend to be impatient with open-ended discussions.

3.2 Existing approaches for identifying learning style

The following table summarizes existing approach for identifying learning styles.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
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<tbody>
<tr>
<td>Kolb Learning Style Inventory (LSI)</td>
<td>It is based on a self-description test which allow students to be aware of the way they learn. The learner is provided with twelve sentences that he/she should complete. For example “When I need to learn…” or “I learn best when…”. At the end of the test, the student is classified into one of the following categories: “Diverging”, “Accommodating”, “Converging”, “Assimilating”</td>
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<tr>
<td>DVC Learning Style Survey for College by Jester</td>
<td>The purpose of DVC Learning Style Survey is to help learners determine their own learning style. It is based on survey that contains 32 questions. For each question, the learner should give an answer on a scale: “Often”, “Sometimes”, and “Seldom”. For example: “would rather read material in a textbook than listen to a lecture.” At the end of the survey, the learner is classified into one of the following categories: “Visual”, “Auditory”, “Tactile/Kinesthetic Learner”. Here is an example.[1]</td>
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<tr>
<td>Learning Style Inventory (LSI) by Barsch</td>
<td>The Learning Style Inventory By Barsh takes the shape of a survey with 24 questions written in the first person. For example, “Can remember more about a subject through listening than reading…”. The learner is required to give an answer on a scale: “Often”, “Sometimes”, “Seldom” At the end of the test, the learner can classify himself into one of the following categories: “Visual”, “Auditory”, “Kinesthetic”, using a scoring procedure: often = 5 points; sometimes = 3; points seldom = 1 point. The result is a score in each category which helps the learner identify his dominant learning style. Here is an example.[2]</td>
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<tr>
<td>Assessing The Learning Strategies of Adults (ATLAS)</td>
<td>Assessing The Learning Strategies of Adults (ATLAS) developed by college professors conti and kolody, it is self-assessment, the questions are related to real-life situation and how learner act. The learner should select the best answer that fits the way he acts in the situation presented. The purpose of this technique is to classify learners according to the learning strategies they use to accomplish a specific learning task. The clusters used are: “Navigators”, “Problem Solvers”, and “Engagers”. Here is an example:[3]</td>
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<tr>
<td>Myers-Briggs Type Indicator (MBTI)</td>
<td>As posited by Isabel Briggs Myers: “It is up to each person to recognize his or her true preferences”. MBTI is a personality inventory, it is an instrument that identifies basic preferences of individuals as well as personality types based on psychological theories. It contains 93 questions and requires 15 minutes. Here is an example [5]</td>
</tr>
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</table>
Bayesian network (BN) [6]

Based on assumption that Bayesian network is a way to represent relationships between parameters in a domain. The authors used BN to represent student behavior while he/she is interacting with the educational web system and then infers the learning style is based on Dimensions of Felders learning styles. The dominant learning style is the one having the greatest probability.

Analyzing the existing approach for identifying learning styles reveals some limitation we should address:

In one hand, in Kolb Learning Style Inventory, learning style dimensions are difficult to capture since they are not easy to understand and also because it is difficult for learners to rate themselves. For DVC Learning Style Survey for College and Learning Style Inventory (LSI) by Barsch, they suggest an efficient clustering of students in well-known categories, namely: "Visual", "Auditory", "Tactile/Kinesthetic Learner". However, providing students with 32 and 24 questions respectively, this requires a considerable effort from students and won't help them get motivated. Most of them are discouraged and complete the self-description test quickly so to get access to the subject-matter they would like to study. To this, it important to take into consideration that it does take time to answer all the questions that are required.

In the other hand, ATLAS and MBTI approach suggest efficient questions that lead to good identification of learning style. However, most of time learners are not aware of their own learning style and in some cases, a learner could be classified into many categories – to some extent- and would be a misunderstanding of learning style. This problem was addressed by another approach which lead to a good estimation of learning style using percentages, this approach is based on an assumption that a learner could be for example 60%visual, 30% auditory and 10% tactile. The technique used is to determine the learning style based on the behaviors of students with the content presented. For instance "Bayesian Netwok", "Markov Model", "Neural Networks", "Ant Colony Algorithm", "Patical Swarm Optimization", those approach give realistic estimations. The results are much more effective than the traditional methods of identifying the learning style but it has notable drawbacks: at the beginning of online learning activity, learn profile hold a little information about the learners, a common problem known as: e-learning cold start problem. Therefore, those algorithms need existing data to generate efficient results.

4 IDENTIFYING LEARNING STYLES BASED ON COMPUTERIZED ADAPTIVE TESTING

In this section we present a new direction to identify the learning style using an online diagnostic test. More specifically, we suggest using Computerized Adaptive Testing: an adaptive questionnaire that collects information about learner knowledge level and learning style. Computerized adaptive will be first introduced followed by their use to identify Learning Style.

4.1 Computerized adaptive testing

Online assessments are used to measure student’s level against a standard of performance. It’s used in adaptive education hypermedia. Such systems need data about student’s level at the beginning of the learning session, so to provide him with tailored teaching learning sequence.

In general, adaptive diagnostic tests are administrated in the form of multiple-choice questions with only textual questions. It is based on assumption that “a very easy or very difficult test would give few information about the examinee level”. The adaptive aspect is used to adapt the questions to the learner level in order to effectively assess his/her level and save the time of answering questions that would give few information about student level. Our research hypothesis is as follow, it would be possible to propose to the learner a set of questions that could identify his learning style based on the interaction of the examinee with this task.

To design adaptive tests, we suggest adapting IRT (Item Response Theory) to our application context. IRT is a latent trait measurement theory. It aims to place the learner in front of a virtual examiner who can make decisions about the questions to ask in order to accurately estimate the learner level. Mathematically, IRT is a probabilistic model that brings together the skill level of an individual to the probability that an individual will succeed in one or more items. The theory is based on the following
assumption: "In a test, the learner response depends on his level of competence but also on the characteristics of the items."

These characteristics are commonly defined as item parameters. Indeed, learner responses throughout an evaluation are considered such as a stochastic process in which the probability of giving a good answer or not depends on several related factors: it could be the questions previously asked or to the learners themselves, such as the cognitive and metacognitive resources, the affective and social components of the latter. According to the IRT, a learner has a probability \( P(e) \) to answer correctly an item, the item in education can take the form of a question. Once calculated, this probability is used to give pertinent questions based on his profile, and the test information.

In this contribution, we suggest to link each question with the underlying traits that helped the learner answer it. For instance, we vary the questions provided to learners according to their learning style based on the previously asked questions and the preference of the learners.

4.2 Using computerized adaptive testing to identify learning style

To apply computerized adaptive testing in order to identify the style of learning we proceed as follows:

1. Build a bank of questions. These questions have the particularity of being presented in distinct formats, in other words, the same question can be asked differently.
2. Use Item Response Theory to design adaptive tests, that is, to provide to learner questions aligned with his learning style during the test.
3. Examine the possibility of identifying learner style through his responses to those adaptive questions.

The following flowchart describes our approach for identifying learning style.

![Flowchart](image)

Fig1. Using Adaptive testing to predict the dominant learning style
5 CONCLUSIONS

Learning styles is one of the student’s key characteristics. Identifying learning style at the beginning of the online course is beneficial since it could be used to provide him with learning material that best match his learning strategies. However, understanding learning style is a challenging research area: in the literature there is many models of learning styles as well as many approaches for identifying them. In our contribution, we pointed out the limits of existing approaches and suggest a new method that could tackle the issue of identifying learning style at the beginning of an online course. This method has many advantages: the test is untimed, so to analyse the behaviour of the student with each question. Another advantage is that each question could be presented in different ways so to conform the learning style of the examinee. To perform adaptation the proposed test is based on computerized adaptive testing theory.

One of the drawbacks of the method proposed is that each question should be modelled differently so to fit the learning style inventory. For instance the same question should be adapted for example to visual learners who prefer picture, graph and to active learners who prefer learning by doing.

REFERENCES


