



## Data mining for adaptive learning sequence in English language instruction

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### ARTICLE INFO

#### Keywords:

Adaptive system analysis  
Data mining  
Teaching English as a Second Language (TESL)

### ABSTRACT

The purpose of this paper is to propose an adaptive system analysis for optimizing learning sequences. The analysis employs a decision tree algorithm, based on students' profiles, to discover the most adaptive learning sequences for a particular teaching content. The profiles were created on the basis of pretesting and posttesting, and from a set of five student characteristics: gender, personality type, cognitive style, learning style, and the students' grades from the previous semester. This paper addresses the problem of adhering to a fixed learning sequence in the traditional method of teaching English, and recommends a rule for setting up an optimal learning sequence for facilitating students' learning processes and for maximizing their learning outcome. By using the technique proposed in this paper, teachers will be able both to lower the cost of teaching and to achieve an optimally adaptive learning sequence for students. The results show that the power of the adaptive learning sequence lies in the way it takes into account students' personal characteristics and performance; for this reason, it constitutes an important innovation in the field of Teaching English as a Second Language (TESL).

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### 1. Introduction

In order to compete and survive in the twenty-first century global economy, it is essential that students acquire communication skills in English (Chen, Warden, & Chang, 2006). The goal of teaching English – including comprehension, listening, speaking, reading, and writing proficiency – is to facilitate students' future academic and professional careers. Students' learning depends on what happens in the classroom, and in different classrooms there may be different cognitive and learning styles. In the conventional learning systems of Taiwan, however, teachers of English teach the same content to all students, without taking into consideration the individual students' gender, personality type, cognitive style, learning style, or previous knowledge. That is, the current courses are based on “static” learning material, not “dynamic” learning material (Romero, Ventura, Delgado, & Bra, 2007). In this type of learning system, if students wish to maximize their learning outcome, they must adapt themselves to the course content, the course content is never adapted to accommodate *their* individual needs and preferences.

Adapting what goes on in the classroom to students' needs involves two important issues: how to tailor courses to each individual students' characteristics and capabilities, and how to create, represent, and maintain the activity tree with the appropriate associated

sequencing definition for different students. Unfortunately, because of the enormous costs universities have to pay for education in Taiwan, it is impossible to design personalized learning environments to accommodate each students' learning needs. It is possible, however, by using a decision tree algorithm, for teachers to investigate students' learning characteristics in advance, and on the basis of this information to extract students' optimal learning sequences, and then maximize students' learning outcome by grouping students with the same learning sequence together. This paper will apply a decision tree algorithm, a data mining technique, to investigate each students' background and characteristics in order to optimize his or her learning sequence and maximize his or her learning outcome in the field of Teaching English as a Second Language (TESL).

### 2. Literature review

#### 2.1. Adaptive learning

Since conventional classroom learning hinders students' potential performance outcomes, it is necessary to devise techniques of adaptation and personalization in order to improve their learning process. Gilbert and Han (1999) proposed the “Case-Based Reasoning” (CBR) system, according to which new students, depending on their prior learning experience, would be assigned to one of four groups – the one deemed most suitable for providing them with adaptive learning materials and maximizing their learning outcome. Shang, Shi, and Chen (2001) argued the necessity of creating

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an intelligent learning environment, one that would be student-centered, self-paced, highly interactive, and based on students' learning characteristics, including background knowledge and learning style. Trantafilou, Poportsis, and Demetriadis (2003) proposed an adaptive learning system called AHS (Adaptive Hypermedia System). In the AHS learning system, students would be divided into two groups with different cognitive learning styles: one group for student demonstrating field independence, the other for those showing field dependence.

Each of these proposals takes account of students' different learning styles, learning characteristics, and learning preferences in order to help them absorb course material more quickly and efficiently (Adler & Rae, 2002; Corno & Snow, 1986; Karagiannidis, Sampson, & Cardinali, 2001). The advantage of adaptive learning is that it offers flexible solutions by dynamically adapting content to each individual's learning needs.

## 2.2. Learning sequence

While using adaptation and personalization techniques to improve the learning process for students, instructors should also consider the sequence in which course material is taught, for it may lie at the heart of the students' learning process. According to the IMS (Simple Sequencing Specification), version 1.0 (2007) definition, sequencing is a predictable, consistent ordering of course material that delivers learning activities in an instructionally meaningful manner, without consideration of the delivery environment. The learning sequence can be specified by either the course instructors or the courseware designers. As for the sequence of the instructional activities, it would be designed after taking full account of the students' learning behaviors and backgrounds (Colace, De Santo, & Vento, 2005). For learning sequence has an effect on navigational elements, while teachers choosing the course content must map a sequence based on students' characteristics in order to facilitate the learning process. That is, teachers should arrange different learning sequences to match each individual students' portfolio and learning content.

Carchiolo, Longheu, and Malgeri (2002) have proposed utilizing adaptive formative paths in a Web-based e-learning environment, using domain database and student profiles to generate a students' personalized learning path. Taking into account each students' prior knowledge and learning characteristics, the learning sequences are dynamically modified to match the students' needs and capacities. Therefore, the adaptive learning sequence system is effective in improving students' learning achievement.

## 2.3. Student characteristics

In order to implement the adaptive learning sequence in the teaching of English, students' characteristics or profiles should be analyzed. It has been shown that the analysis of students' learning characteristics and profiles can help teachers understand the reasons why students get high or low grades, by revealing the implicit rules students follow during the learning process (Sarasubm, 1998; Su, Tseng, Wang, & Weng, 2006). One of the most telling factors to be considered is whether a students' cognitive style is field dependence or field independence (Witkin, 1962; Witkin, Moore, Goodenough, & Cox, 1977). Many researchers have demonstrated the impact of field dependence/field independence cognitive styles on students' learning (Abraham, 1983; Brumby, 1982; Jamieson & Chapelle, 1987; Summerville, 1999; Witkin, 1962; Witkin et al., 1977). It has also been demonstrated that motivation plays an important role in learning a foreign language (Manolopoulou-Sergi, 2004; Robinson, 2003; Skehan, 1998). That is, providing students with the proper motivation can enhance their ability to learn a new language. In addition, the combination of learning styles and

teaching strategies has been carried out in a variety of educational contexts (Chen, Liu, Ou, & Liu, 2000; Chiali, Eberrihi, & Malki, 2006; Evans, 2004).

While analyzing students' learning characteristics, Chen et al. (2000) applied decision tree and data cube techniques to investigate students' learning behaviors and observe learning processes to find out the pedagogical rules on students' learning performance. By taking account of students' learning profiles, Chen's decision tree and data cube techniques can offer students with similar learning characteristics and profiles appropriately personalized recommendations. Furthermore, student profiles can be used in adapting course materials and learning sequences (Chiali et al., 2006; Evans, 2004; Sarasubm, 1998).

## 2.4. Data mining

Data mining is a technique for uncovering hidden patterns in the object or process described in the data. The uses of data mining include the following. In the first place, by using the technique of data mining, a little data can be made to reveal many new patterns and new relationships. Second, data mining can disclose new ways to classify data and can find clusters and associations within data. Third, data mining can discover new ways of facilitating better decision making (Devroye, Gyprfi, & Lugosi, 1997). Romero, Ventura, and Bra (2004) used evolutionary algorithms as a data mining technique to discover interesting relationships in students' usage data, which may be very useful to both teachers and course designers in maximizing the effectiveness of a given course. Lee (2005) proposed a student model in the context of an integrated learning environment in which diagnostic, predictive, and compositional modeling were discussed. Both diagnostic and predictive modeling are applied to issues of credit assignment and scalability. Compositional modeling of student profiles is used in the context of an intelligent tutoring system/adaptive hypermedia learning system pattern. Hsia, Shie, and Chen (2006) used data mining techniques to uncover the preferences and predict the future choices of Continuing Education students at the Extension Education Center of a university in Taiwan. Hence, by using the data mining technique, being referred to as database knowledge discovery, an implicit pattern will be elicited from a volume of data (Klogsen & Zytow, 2002; Su et al., 2006).

## 2.5. Decision tree analysis

A decision tree is a popular technique used for supervising. A number of papers have demonstrated the successful application of decision tree models to real-world problems (Luan, 2002; Pliomis, 2004; Timmermans & Arentze, 2003; Zalik, 2005). A decision tree is a tool used in the description, classification, and generalization of data. It can organize descriptions of data into more compact form. It can also classify data into groups sharing similar features and characteristics. And it can be used to generalize and predict the value of dependent variables through mapping from observations about independent and dependent variables to make a conclusion about these variables' target value (Murthy, 1998).

A decision tree can thus take the form of an algorithm that uses information to search for prediction rules and further analyze the results of classification (Hsia et al., 2006). In research, decision trees have the following advantages. They can be effectively applied to all types of data structure, discrete, continuous, or mixed. In addition, the prediction rules of a decision tree are easily interpreted. Finally, it can predict accurately even in the case of highly non-linear problems (Hautaniemi, Kharait, Iwabu, Wells, & Lauf-fenburger, 2005). In sum, a decision tree can be an important tool in data mining.

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